ARS-BLM COOPERATIVE STUDIES

REYNOLDS CREEK WATERSHED

Northwest Watershed Research Center
Western Region
Agricultural Research Service
U. S. Department of Agriculture

INTERIM REPORT NO. 7

Cooperative Agreement No. 14-11-0001-4162(N)

For Period January 1, 1976 to December 31, 1976

TO

Denver Service Center
Bureau of Land Management
U. S. Department of the Interior
Denver, Colorado

MARCH 1977

NOTE

Generally, a variety of watershed data are compiled on a calendar year basis. However, the water year, beginning October 1 and ending September 30, has proven best for hydrologic comparisons.

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INTRODUCTION

Cooperative watershed research between the Agricultural Research Service, U. S. Department of Agriculture, and the Bureau of Land Management, U. S. Department of the Interior, was initiated in 1968 under Cooperative Agreement No. 14-11-0001-4162(N). Also, the Memorandum of Understanding, dated July 6, 1961, which is a part of the Cooperative Agreement, specifies the overall responsibility of each agency.

This interim report summarizes progress and results from January 1 through December 31, 1976, as outlined in the work plan for F.Y. 1977. The report also describes the proposed activities and changes in objectives for consideration in the F.Y. 1978 work plan.

Data collection, processing, and analysis continued according to the F.Y. 1976 work plan and details of progress and accomplishments are described in each section of the report. Further information is contained in Northwest Watershed Research Center Annual Reports for 1972 and prior years, and in Interim Report Nos. 1, 2, 3, 4, 5, and 6 of ARS-BLM studies in the Reynolds Creek Watershed under Cooperative Agreement No. 14-11-0001-4162(N).

In addition to ongoing studies on the Reynolds Creek Watershed, the following supporting studies have been initiated:

On the Boise Front, cooperative watershed research with the Idaho Fish and Game Department, USDI - Bureau of Land Management, and USDA - Soil Conservation Service and the Forest Service, has been initiated in the Lucky Peak Resource Management Unit. The Unit, consisting of 15,740 acres, has been divided into eight pastures on which a 4-year rest-rotation grazing system has been established for summer grazing. The unit is also the winter browse area for the largest deer herd in Idaho.

The ARS research objectives in this cooperative study are to determine the effects of the rest-rotation grazing and deer management system on runoff and water yield, sediment yield, vegetation composition and cover, and water quality. An opportunity will also develop from this study to compare Boise Front watershed data with watershed data from the ARS Reynolds Creek Watershed, giving a measure of Reynolds Creek data applicability.

The details of the Boise Front collection program are discussed in the following sections of this report. Figure 1 depicts the experimental area.

The 4-year data base of water quality parameters and associated hydrologic parameters on the Reynolds Creek Watershed, predominantly for the grazing season, will be supplemented by a cooperative project with the University of Idaho.

A study of water quality associated with the wintering phase of rangeland livestock enterprise, has been initiated. The planning of this study will focus on evaluating runoff control practices. These are discussed in the water quality section.

Cooperative research with the Soil Conservation Service on their SNOTEL program has accelerated snow hydrology research on testing hydrometeorological sensors and water supply forecasting. This work is primarily located in the Boise River Basin. A summary of this project is in the snow section. A complete progress report is available upon request.

Weather and Runoff - 1976

Snow accumulations on Reynolds Creek Watershed were near normal levels. Snowmelt runoff was predicted at Tollgate weir to be 109 percent of average, and runoff during the 1976 water year was 98 percent of the 1966-76 average.

The total precipitation for the first nine months of 1976, was about average, because of the above average precipitation in July, August, and September. Precipitation during the last week of July accounted for most of the precipitation during the month. This wet period was followed by a considerable amount of precipitation the first week of August. These two weeks caused considerable vegetal growth on the entire watershed. The much above average precipitation in September fell during a 6-day period in mid-September. This also caused considerable vegetal growth after mid-September.

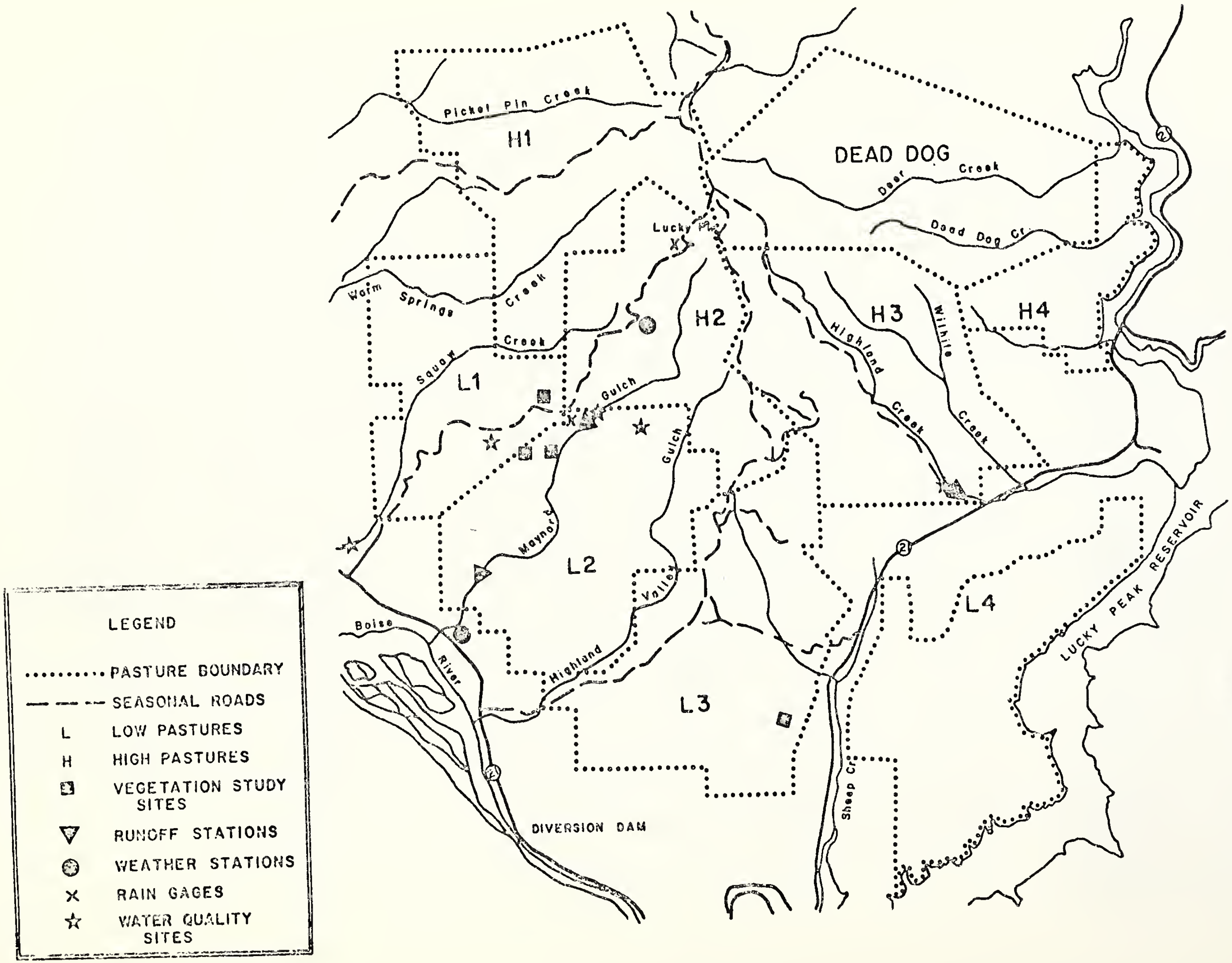
The last three months of the year were very dry, which accounted for the below average annual amounts. In fact, the total for the three months was less than the average for any one of these months. Temperatures were average throughout the year. Soil water conditions are extremely low going into the 1977 winter season. Grazing conditions during the summer were good.

Cooperative Project Recognition

The 1975 American Geophysical Union Horton Award, presented annually to the outstanding hydrology paper, was awarded for the paper "Use of Axisymmetric Infiltration Model and Field Data to Determine Hydraulic Properties of Soils" by R. W. Jeppson, W. J. Rawls, W. R. Hamon, and D. L. Schreiber. (Water Resources Research 11(1): 127-138.) This work was under the ARS-BLM cooperative agreement. The abstract of this paper follows:

> "A numerical model is described for solving axisymmetric infiltration problems. The model uses saturation-capillary pressure data and a modified Burdine equation to develop reasonable estimates of relative hydraulic conductivity.

A specially designed infiltrometer and a field data collection system, which provide infiltration capacity, saturation-time, and saturation-capillary pressure data, are also described. The numerical solutions were fitted to the field data to define the hydraulic properties of the soil. Close agreement was found between the numerical model solutions and the field measurements for two sites on the Reynolds Creek Watershed in southwestern Idaho. A feasible method was developed for determining the hydraulic properties of surface soils under natural conditions".



Introduction Figure 1.

STAFF

Aaron, Virginia M.	Hydrologic Technician (Perm., 35 hr/wk)	
Barrett, Laura	Clerk Typist (Perm., 35 hr/wk)	6/20/76 - 10/9/76
Bendio, Ruric E.	Boise State University Cooperator - Technician	12/9/75 - Present
Bowles, Leon	Boise State University Cooperator - Technician	5/16/76 - 8/28/76
Brakensiek, Donald L.	Research Hydraulic Engineer (LL & RL)	
Burgess, Michael D.	Electronic Technician (Perm., 39 hr/wk)	
Butler, Donna M.	Administrative Officer	
Coon, Delbert L.	Hydrologic Technician	
Cox, Lloyd M.	Hydrologist	
Engleman, Roger L.	Mathematician	
Fowers, Linda	Boise State University Cooperator - Technician	5/16/76 - Present
Gidley, Jess R.	Hydrologic Aid (Temp., 16 hr/wk)	
Hanson, Clayton L.	Agricultural Engineer	
Harris, James	Boise State University Cooperator - Technician	5/11/76 - Present
Hermann, Ralph F.	Carpenter (Perm., 24 hr/wk)	Retired - 1/15/77
Herrington, Mary	Boise State University Cooperator - Technician	6/1/75 - 9/18/76
Hoagland, Roy M.	Automotive Mechanic	
Johnson, Clifton W.	Research Hydraulic Engineer	
Moreland, Bonnie	Clerk Typist (Perm., 35 hr/wk)	1/2/77 - Present
Morris, Ronald P.	Hydrologic Technician	
Nelson, Darlene F.	Clerk Stenographer (Perm., 35 hr/wk)	9/12/76 - Present
Nydeggar, Nicholas	Boise State University Cooperator - Technician	5/16/76 - 8/21/76
Perkins, Lee	Hydrologic Technician	
Robertson, David C.	Hydrologic Technician	
Schumaker, Gilbert A.	Soil Scientist	
Smith, Jeffrey P.	Hydrologic Technician	10/12/75 - Present
Stephenson, Gordon R.	Geologist	
Street, Leah V.	Biologic Technician (Soils)	9/14/75 - 8/12/76 Intermittent
Thomson, Michael S.	Hydrologic Aid (Temp., 16 hr/wk)	
Trautman, Kenneth W.	Engineering Equipment Operator	
Walton, Dala S.	Clerk Stenographer (Perm., 35 hr/wk)	Resigned 8/27/76
Wilson, Glenna A.	Procurement Clerk	
Wingfield, Elaine M.	Clerk Stenographer (Temp.)	3/14/76 - 5/28/76
Zelinsky, Ann	Boise State University Cooperator - Technician	10/19/76 - 12/13/76
Zuzel, John F.	Hydrologist (Educational Leave, University of Washington)	9/19/76 - 6/12/77

PRECIPITATION

Title: Precipitation characteristics of a northern, mountainous, semi-arid watershed.

Personnel Involved:

C. L. Hanson, Agricultural Engineer	Supervise experimental planning, design, analyses, and reporting.
R. L. Engleman, Mathematician	Assist in data analyses and reporting results.
V. M. Aaron, Hydrologic Technician	Assist in data reduction analyses, and reporting results.
R. P. Morris, Hydrologic Technician	Assist in data reduction analyses, and reporting results.

Date of Initiation: 1961

Expected Termination Date: Continuing

INTRODUCTION

The rain gage network on Reynolds Creek Experimental Watershed was established to describe the temporal and spatial precipitation distribution on a mountainous watershed. National Weather Service data collection stations are generally located in or near the main cities. Since these are generally along the main stems of major streams or in valleys, a sampling of precipitation on the range watershed areas is not available from their records. Also, there are too few rain gages capable of recording intensities or even individual storm data.

Objectives:

1. To develop and compute parameters that characterize precipitation rates and amounts for application to runoff and erosion predictions.

2. To establish general precipitation-elevation-aspect-slope-relationships from precipitation data obtained in the Reynolds Creek Experimental Watershed for hydrologic and forage production forecasting.

3. To develop depth-duration-frequency and depth-area-duration relationships for the Reynolds Creek Experimental Watershed for application to similar rangeland areas.

4. To formulate and test methods that predict precipitation inputs to hydrologic models for the Reynolds Creek Experimental Watershed and similar rangeland areas.

PROGRESS

Reynolds Creek

Precipitation data collection was continued in the Reynolds Creek Watershed from 26 dual-gage sites, Figure 1. The number of rain gage sites was reduced to 26 from 52 the first week of January 1976. All of the 1962-1976 data have been processed. A 15-year record is now available for analysis.

The 1976 and 8-year (1968-1975) average precipitation for three representative watershed sites are listed in Table 1.

Boise Front

The three higher elevation dual-gage precipitation sites were installed on the Boise Front in September 1976 (Introduction Figure 1). Another site near the outlet of Maynard Gulch will be installed in February 1977. These sites were established to monitor precipitation as an integral part of the Boise Front grazing investigation. This precipitation network will also be used to test models developed from the network on the Reynolds Creek Experimental Watershed.

The upper weather station, shown on Introduction Figure 1, was installed in September 1976, and the weather station near the outlet of Maynard Gulch will be installed in February 1977. Each weather station has a recording hygrothermograph, recording wind direction and velocity, frost measuring devices, and a recording evaporation pan.

SIGNIFICANT FINDINGS

The 1962-1976 data from the Reynolds Creek Experimental Watershed was processed and is now in computer compatible form so that these data are now readily accessible for future analysis and modeling efforts.

WORK PLAN FOR FY 78

1. Stochastic models, describing temporal and spatial variations involving annual, monthly, and daily time increments, will be developed and tested for the Reynolds Creek Experimental Watershed and the State of Idaho.

2. General precipitation-elevation-aspect-slope-vegetative cover relationships will be investigated for hydrologic and forage production forecasting.

TABLE 1.-- 1976 Precipitation Summary at Three Locations on Reynolds Creek Watershed.

Site	Elevation	Date	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
076X59	3965	1976	.95	1.68	.61	.47	.39	.70	.58	.85	1.27	.28	.15	.07	8.00
		1968-75	1.69	.71	1.26	.95	.41	1.28	.32	.80	.48	1.15	1.15	1.21	11.41
116X91	4760	1976	1.64	2.58	1.55	1.13	.78	1.27	.75	.88	1.51	.76	.09	.18	13.12
		1968-75	3.09	1.47	2.29	1.80	.72	1.50	.40	.71	.80	1.97	2.07	2.48	19.30
176X07	6760	1976	6.93	7.07	3.99	2.76	1.01	1.74	.77	1.47	1.78	1.43	.45	.35	29.75
		1968-75	8.32	4.71	5.17	3.31	1.67	2.26	.71	1.15	1.15	2.83	5.02	7.13	43.43

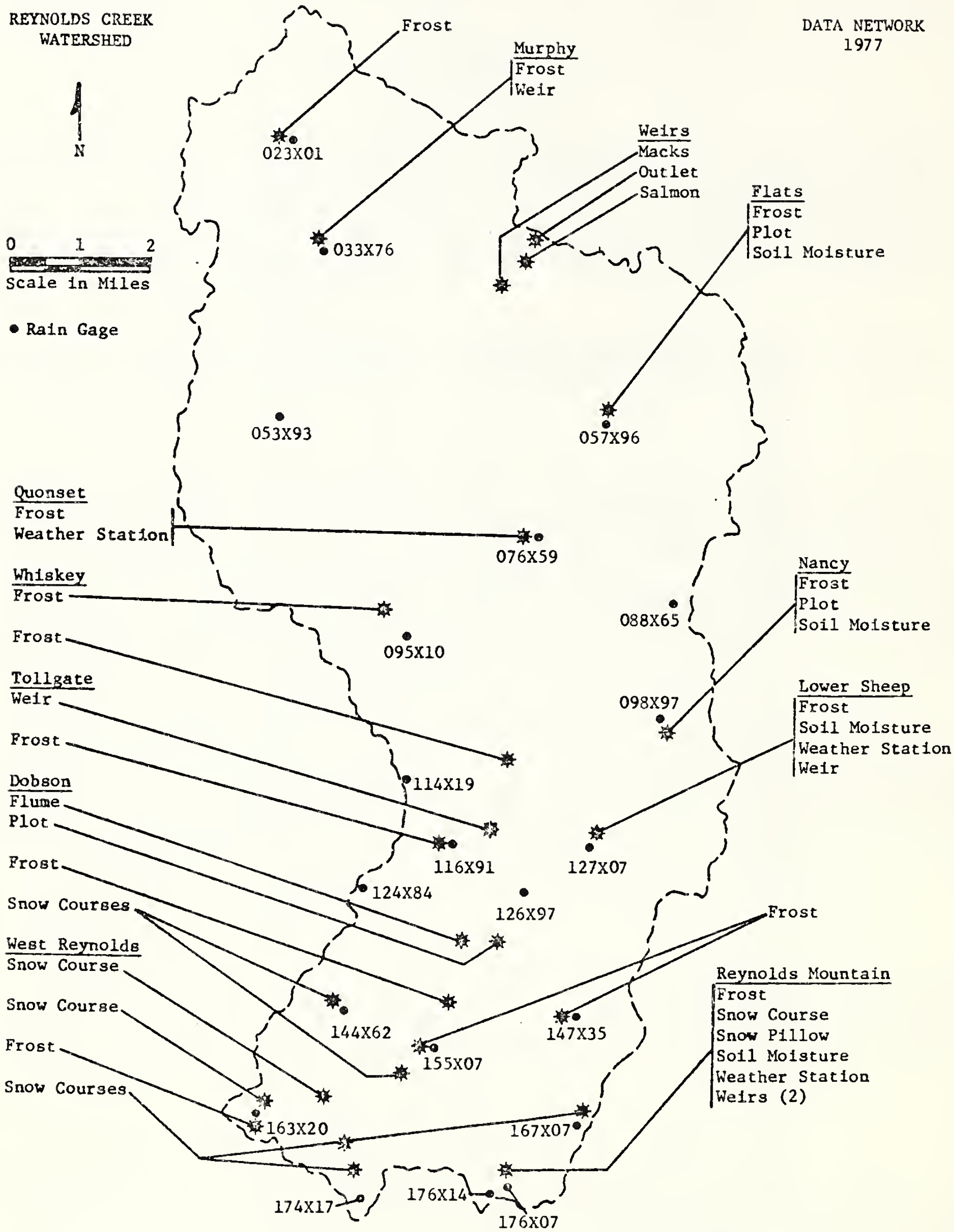


Figure 1. Reynolds Creek Watershed, 1977 Data Network.

Title: Snow accumulation, snow redistribution, and snowmelt

Personnel Involved:

L. M. Cox, Hydrologist	Supervise the planning, designing, execution, analyzing, and reporting of experiments involving meteorological sensor, snow water equivalent and precipitation gage testing special snowmelt and snow management studies. Assist in development of a real-time combination forecast model for the Boise River Watershed and snowmelt prediction model for rangeland watersheds.
J. F. Zuzel, Hydrologist	Supervise the planning, designing, and development of a real-time combination forecast model for the Boise River Watershed and snowmelt prediction model for rangeland watersheds. Assist in analyzing experiments involving meteorological sensor snow water equivalent and precipitation gage testing and snow management studies.
D. C. Robertson, Hydrologic Technician	Assist in the planning, designing, execution, analyzing, and reporting of proposed experiments. Supervise all data processing and data reduction from all sites in the Boise River Watershed and Reynolds Creek Watershed.
L. Perkins, Hydrologic Technician	Assist in the planning, designing, execution, analyzing, and reporting of proposed experiments.
M. D. Burgess, Electronic Technician	Designs, fabricates, and services electronic sensors and recording systems and radio telemetry systems.
L. Fowers	Assist in data processing and data reduction.

Date of Initiation: 1961

Expected Termination Date: Continuing

INTRODUCTION

Reynolds Creek

A substantial proportion of the runoff from the western rangelands has its origin in rapid melting snow. To improve the quantity or timing of flow from snow-fed streams by manipulation of vegetation or by other practices requires that the behavior of snow be well understood. There has been little research on the behavior of snow in shrub areas--and almost none in the sagebrush areas of the northwest.

Destructive late winter and spring floods in the northwest frequently originate from rapid melting snow at low elevations characteristic of the sagebrush zone. Although there is little likelihood of modifying snowmelt rates enough to alleviate this threat, knowledge about the behavior of snow in the sagebrush zone will be helpful in devising better warning and forecasting techniques that may reduce the danger to life and property from snowmelt floods.

Boise River

Water from snowmelt constitutes over 75 percent of the available supplies in the West. For many years, snow-water equivalent and related hydrometeorological data have been collected manually by the Soil Conservation Service in the Western mountains. These data, as processed and analyzed, have provided water forecasts to a wide range of private, state, and federal water users for management and regulatory purposes. Under the name of "SNOTEL" the Soil Conservation Service is currently involved in upgrading their water supply forecasting program. This involves an upgrading of their hydrometeorological data sensing at snow course sites, data storage and retrieval systems, and improving their water supply forecasts both in accuracy and in forecast time frame - approaching real time.

There exists a need to accelerate research on solving the problems of sensing snow-water equivalent and related meteorological data at remote mountainous sites, transmitting these data to collection centers, and then verifying for integrity and errors; and, improving water supply forecast models, utilizing hydrometeorological data for making short-term and long-term forecasts.

Objectives:

Reynolds Creek

1. To determine the physical and meteorological factors contributing to nonuniformity of snow accumulation in shrub-covered study basins on mountainous terrain.

2. To improve snowmelt prediction techniques by evaluating the energy exchange process of the snow surface under different snow cover conditions.

3. To study the oasis effect of isolated, late-lying snowdrifts for potential management that minimizes evaporative losses and maximizes and prolongs water yield from snowmelt.

Boise River

1. To determine which hydrometeorological sensors are best suited for acquiring quality snow-water equivalent and meteorological data from remote mountainous sites during snow accumulation and melt periods in the Boise River Basin.

2. To improve water supply forecasts both in accuracy and in forecast time frame - approaching real time.

PROGRESS

Reynolds Creek

Snowmelt Model:

Five days of snowmelt and evaporation data were collected in June from isolated drifts. Inclement weather conditions in early June shortened the projected study period.

The snowmelt model was tested by using meteorological data for an evaporation event at Marmont Creek Watershed, Alberta, Canada. The model was originally developed for the isolated snowdrift situation where evaporation usually occurs at the potential rate. As expected, the model greatly overestimated evaporation, because of the large vapor pressure gradients that were present and the limited amount of heat input available to satisfy the heat of vaporization requirement. The limited heat input was due to the low air temperature and the high night time radiative heat losses.

Snowdrift surface profiles:

Three snowdrift surface profiles were surveyed on the SOCAB drift during the melt season and two for the Pet drift (Figure 1). These profiles are used for independent checks of snowmelt models and snowdrift management studies.

The March 23 survey of the SOCAB drift represents maximum accumulation and indicates a drift center cross-sectional area of 168.25 m^2. By comparison, the maximum cross-sectional area recorded last year was

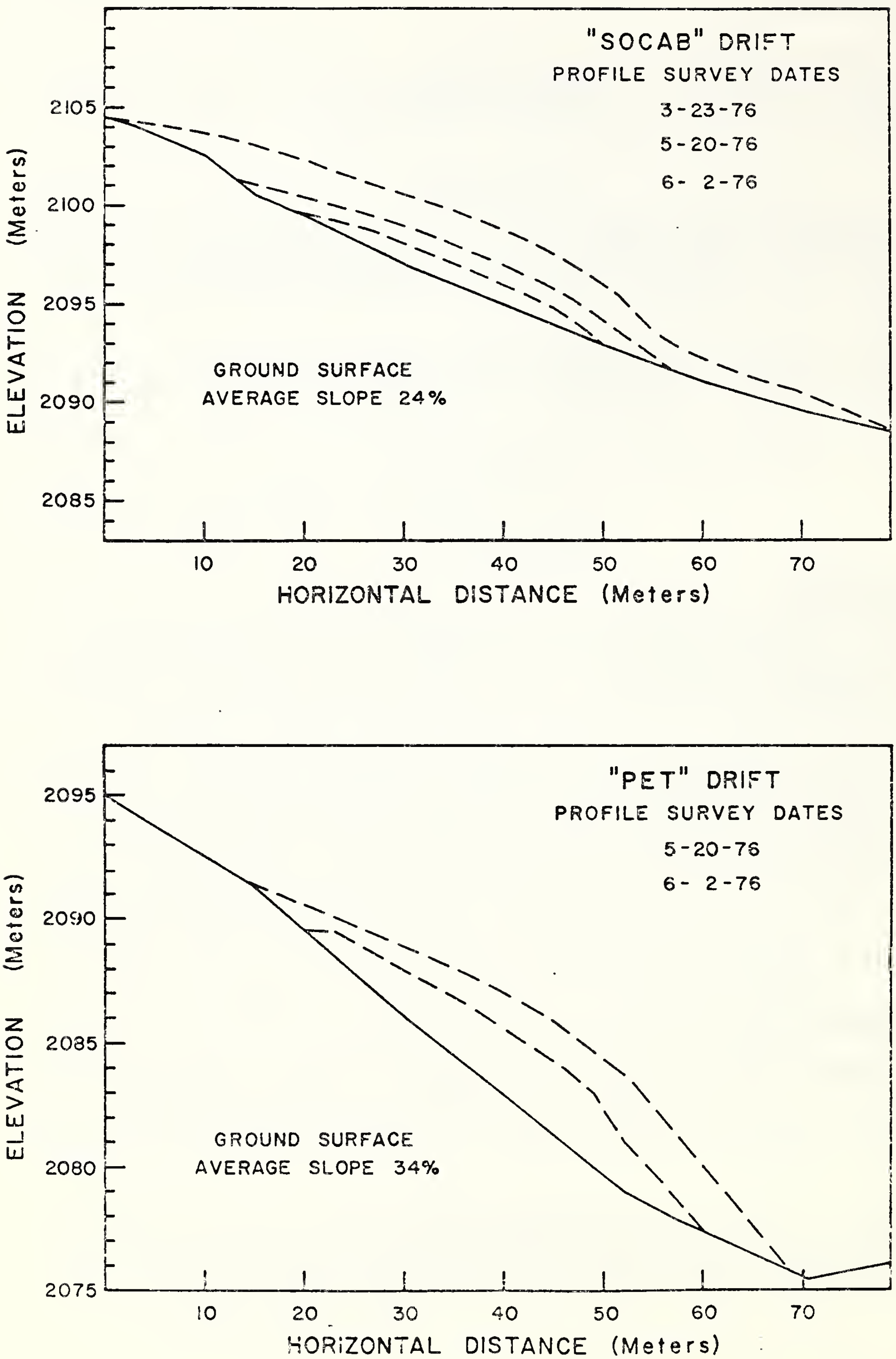


Figure 1. Snow surface profiles for PET and SOCAB snowdrifts during 1976 snowmelt season.

267.87 m^2. The decrease is also reflected in the maximum water stored at the adjacent snow course (176007) of 662.94 mm of water equivalent for 1976, as compared to 934.72 mm of water equivalent for 1975.

Additional surveys at the SOCAB site were conducted at maximum accumulation and on bare ground, to better describe snowdrift volume.

On the May 20th survey date, the drift center cross-sectional area had been reduced by 64 percent with only 60.12 m^2 left. By June 2, only 19 percent of the total maximum cross-sectional area was still in storage. The water in storage at the SOCAB site could have been dramatically altered if a snow fence had been installed. Figure 2 indicates the maximum snow accumulation predicted by Tabler's model (1975)[1/]. Assuming only that snowmelt occurred at the same rate, then between the first two survey dates, only 50 percent of the cross-sectional area would have been lost. Then, only 7 percent of the cross-sectional area would have ablated between the next two dates, resulting in 43 percent of the total cross-sectional area still present on June 2, compared to the actual 19 percent.

In late August, a 3 m high, 50 percent density, vertical slot snow fence was installed along 97.5 m of the SOCAB site. The top of the fence is maintained level, while the bottom conforms to the ground surface contour with a 30 cm gap between the bottom of the fence and the ground surface (Figure 3). The fence is supported by three 3/8-inch aircraft cables, strung through the top, middle, and bottom of wooden posts, placed at about 6 m intervals. The cables are anchored at each end by "deadmen" and the posts are braced on each side of the fence for both SW and NE winds. Survey lines were run on the east and west sides of the original center line (Figure 4), to define the accumulation site.

A ground survey was made at the West Reynolds drift site, another potential study site.

Boise River

During the summer, Landsat-I data platforms were removed from the Graham and Trinity Mountain evaluation sites. Data transmission from these and other sites in the Boise Basin will be accomplished by radio telemetry. Because of equipment failures, long turnaround time, and limited data retrieval times, data acquisition by Landsat-I was considered inadequate for real-time applications.

1/ Tabler, Ronald D. 1975
Predicting profiles of snowdrifts in topographic catchments. Proceedings of the 43rd Western Snow Conference, April 23-25, Coronado, Calif., pp 87-97.

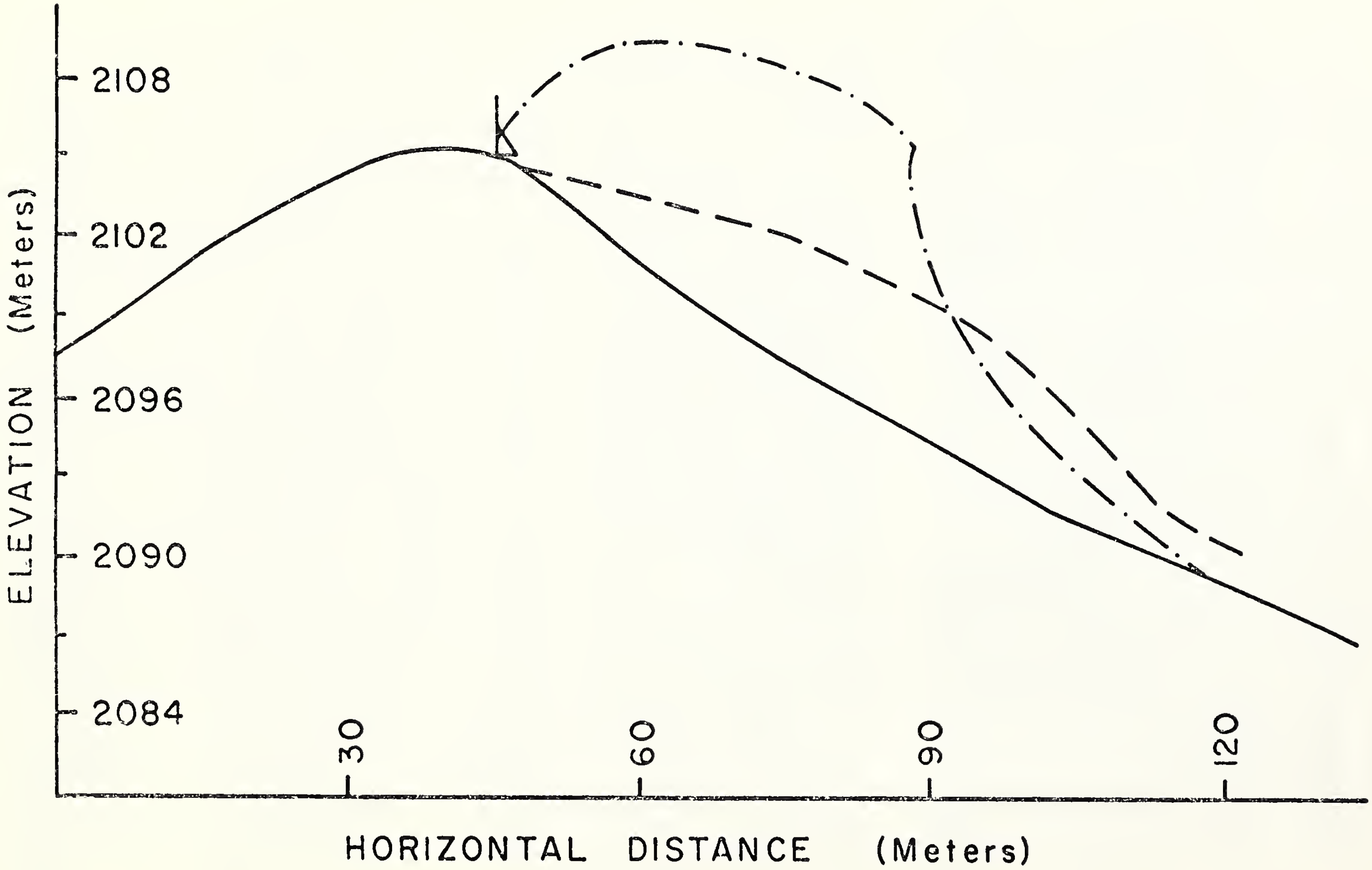


Figure 2. Comparison of measured snow surface profile and predicted surface profile that would result by placing snow fence at SOCAB drift site.

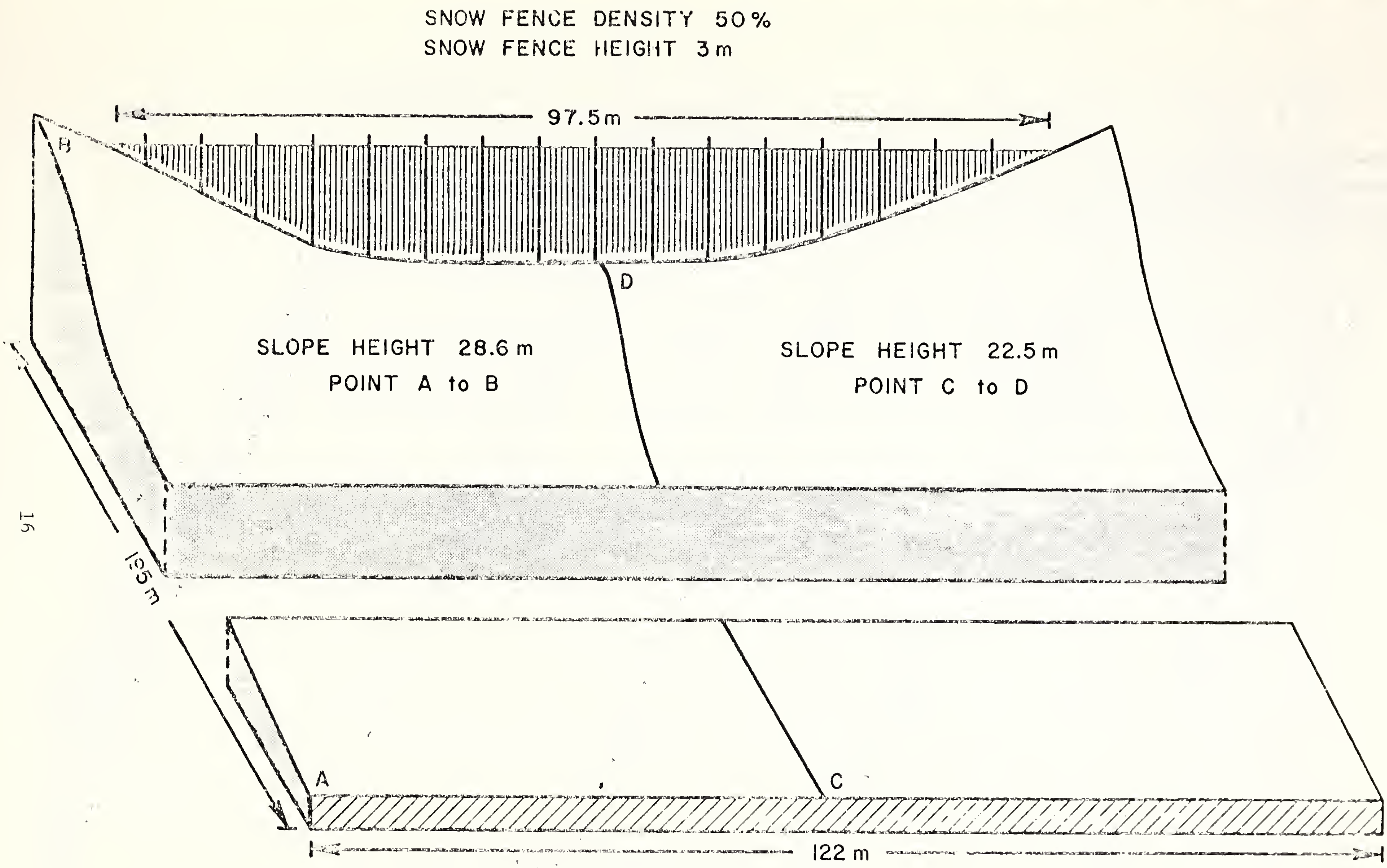


Figure 3. Schematic of snow fence installed at SOCAB drift site.

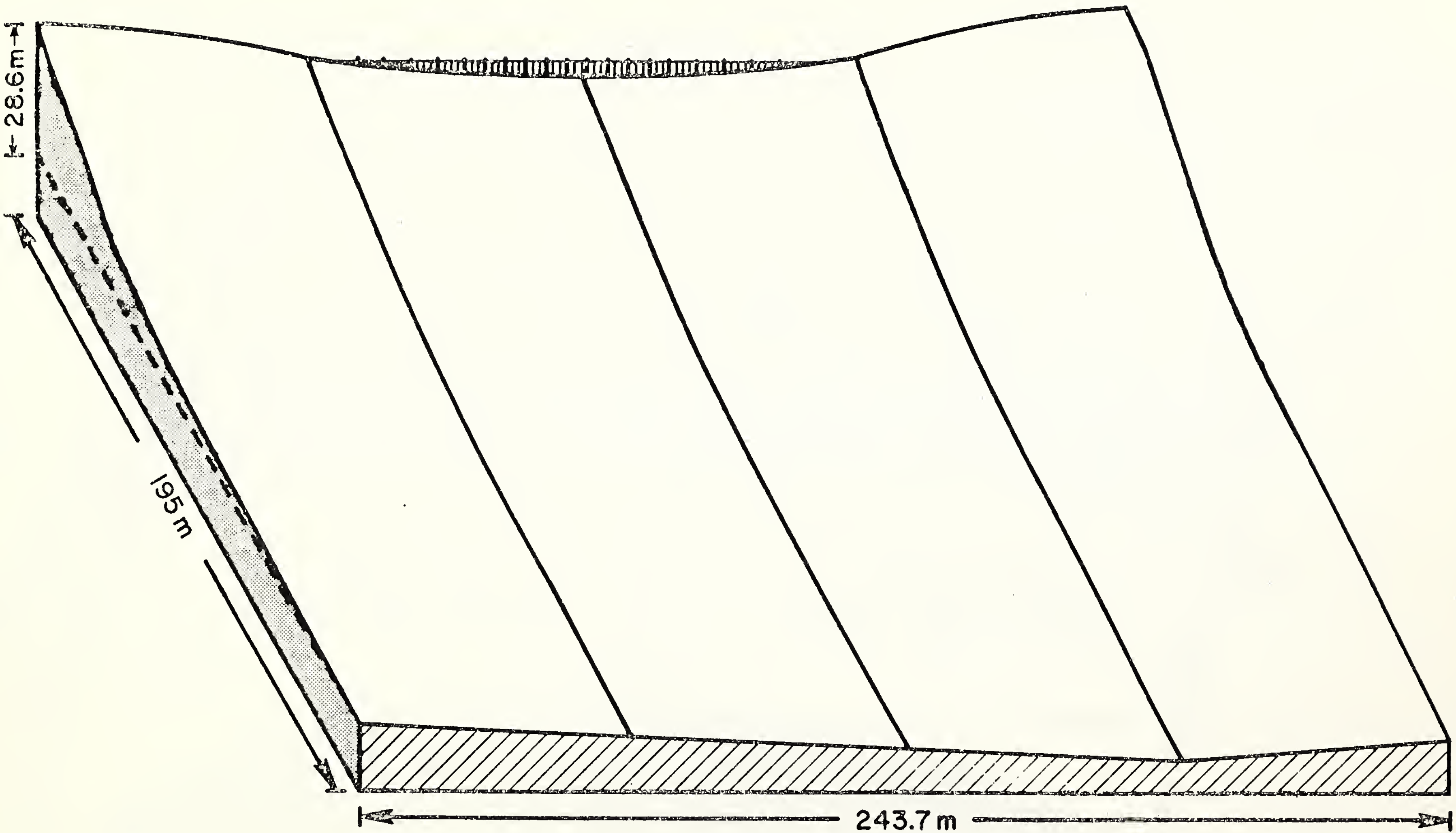


Figure 4. Snow fence at SOCAB drift site showing five survey lines measuring snow surface profiles.

Mean daily flow and monthly summaries for years 1950 to present, for the Featherville and Twin Springs streamflow stations on the Boise River, have been placed on magnetic tape. Data for all snow courses in and associated with the Boise River drainage have also been reduced to magnetic tape. Figure 5 is a location map, showing the location of the three evaluation sites, Trinity Mountain, Graham, and Mores Creek; three stream gaging sites, Troutdale, Twin Springs, and Featherville; and basin snow courses.

ARS has on order a Declab 11L34-CA, multiprogrammable, Disc Based mini-computer that will be interfaced with the radio telemetry system for automatically interrogating all six sites.

A tabulation of all the instrumentation installed at the evaluation sites is shown in Table 1.

Table 1.--Instrumentation at Study Sites (as of October 1, 1976).

Type	Trinity	Graham G.S.	Mores Creek
Instrument Shelter	X	X	X
Instrumentation Tower	X	X	X
Precipitation Gage (SNOTEL)	X	X	X
*Precipitation Gage (DPG, Idaho Industrial Instruments (I^3))		X	
Snow Gage (RSG, I^3)	X	X	X
Snow Pillows (SNOTEL)	X	X	X
SCS Radio Telemetry System	X		X
Landsat-I Telemetry System	X1/	X1/	
Shielded Precipitation Gage (Belfort)	X	X	
Unshielded Precipitation Gage (Belfort)	X	X	
Air Temperature Sensors		X	
Air Temperature Sensors (Diode, ARS Design)	X	X	
Dewpoint Sensors (Panametrics)		X	
Wind Sensors (Cup Anemometers)	X	X	
Data Acquisition System (I^3)		X	X
Data Acquisition System (ARS Design)	X	X	

1/ Removed July 1976

*Trade names and company names are included for the benefit of the reader and do not imply any endorsement or preferential treatment of the product listed by the U.S. Department of Agriculture.

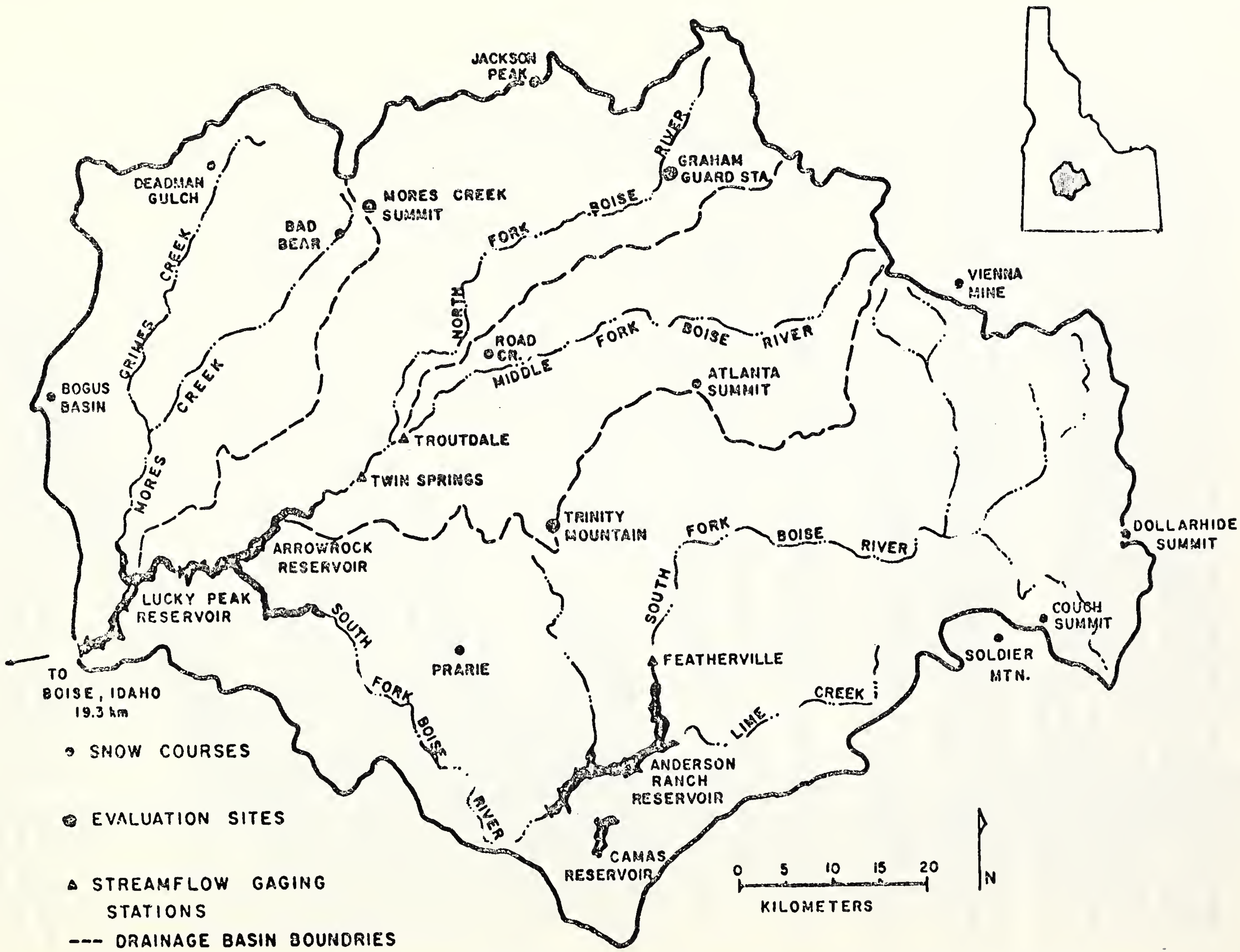


Figure 5. Map of Boise River showing location of snow courses, gaging station, and data sites.

Hydrometeorological sensor evaluations:

Analysis of all the snow water equivalent (SWE) sensors tested indicated that anyone could be used to predict SWE at the snow course for 15-day periods. Daily data indicated that diurnal noise fluctuations in the data acquisition and/or recording systems must be minimized before real-time forecasting can be attempted.

Special snowmelt study:

Special snowmelt data was collected at Trinity Mountain for expanding the data base for research on snowmelt modeling. During the 18-day period at Trinity, there were 428.0 mm of melt, 21.0 mm of precipitation, 22.6 mm of condensation, and 69.7 mm of evaporation recorded. The runoff at the Twin Springs streamflow site was 104 mm. Daily runoff, calculated by a multiple regression equation with daily runoff and daily snowmelt as the independent variables and the next day's runoff as the dependent variable, had a standard error of only 8 percent. During this study period, 58 percent of the total heat input used in the ablation of 498 mm of water came from net radiation.

Additional detail on the ARS-SCS cooperative studies is available in:

Snotel Sensor Evaluation and Forecast Development Study
Interim Report No. 1
Cooperative Agreement No. 12-14-5001-6404
Period July 1, 1975 to September 30, 1976

Northwest Watershed Research Center
ARS-USDA, Boise, Idaho

SIGNIFICANT FINDINGS

Because of equipment failures, long turnaround time, and limited data retrieval times, data acquisition by Landsat-I was considered inadequate for real-time applications.

Prediction equations developed for any of the snow water equivalent sensors data can be used to satisfactorily predict average SWE at the snow course for 15-day time periods. Data from the Graham site indicate that as real-time forecasting is attempted, diurnal noise fluctuations in the data acquisition and/or recording systems must first be minimized.

A snowdrift prediction model indicates that on June 2, 24 percent more water would have been in storage at the SOCAB snow accumulation site if a snow fence had been in place. This indicates that the period of water yield can be dramatically lengthened from this site.

WORK PLAN FOR FY 78

Reynolds Creek

1. Conduct special snow study on late-season snowdrifts for testing a snowdrift snowmelt model.

2. Obtain snowdrift surface profiles at the Pet and SOCAB drift sites, for testing and refining snowdrift surface profile prediction model.

3. Conduct snowdrift surface profile at SOCAB drift site, for evaluating the effects of a 3 m high, 50 percent density, snow fence on snow ablation.

Boise River

1. Conduct an in-depth sensor performance evaluation by comparing sensors with each other and with known values of the measured parameters.

2. Compare computed actual precipitation from the ARS gages with that collected from the digital precipitation gage and the SNOTEL gage.

3. Compare snow-water equivalent as measured by RSG gage, SNOTEL pressure pillow, and federal snow sampler, with that measured by actual weight.

4. Analyze Boise River flow and snow course data for previous years, by computing correlation, cross-correlation, and autocorrelation coefficients for various lag times.

5. Conduct special snowmelt studies at Trinity Mountain and Graham Guard Station during May-June 1977 to increase the data base needed for the short-term portion of the combination forecast model.

6. Install computer-based radio telemetry data collection systems at Trinity Mountain, Graham Guard Station, and Mores Creek Summit for real-time data collection of meteorological and snowpack parameters.

7. Install computer-based radio telemetry data collection systems at stream gaging stations (Twin Springs, Featherville, and Troutdale) for real-time data collection of streamflow, precipitation, and temperature data.

REPORTS AND PUBLICATIONS

USDA-ARS 1976
Nature's Reservoir. Picture Story 293. Office of Communications, U.S. Department of Agriculture. Washington, D.C. 20250. January.

Cox, Lloyd M., John F. Zuzel, and Lee Perkins 1976
A device for evaluating the water vapor exchange between snow and air. Water Resources Research 12(1): 22.

Cox, Lloyd M. and John F. Zuzel 1976
Snowmelt runoff forecast parameter sensing via Landsat-I for the Boise River Basin, Idaho. Prepared for ARS Remote Sensing Workshop. McAllen, Texas. March 23-25.

Chambers, Gale 1976
At long last, they are doing something about the weather. Idaho Farmer Stockman. p 40-41. April 18.

Cox, L. M. and J. F. Zuzel 1976
A method for determining sensible heat transfer to late-lying snow drifts. Presented at 44th Annual Meeting of Western Snow Conference, Calgary, Alberta, Canada. Published in Proceedings 44th Annual Meeting of Western Snow Conference. April 20-22.

Cox, L. M. and et al. 1976
Snotel sensor evaluation and forecast development study. Interim Report No. 1. Northwest Watershed Research Center, ARS-USDA. Boise, Idaho. pp 19.

Cox, L. M. 1976
The energy exchange and microclimate of snow. Invitational paper presented at joint symposium of wintertime soil and microclimate conditions at national meeting of American Society of Agronomy and American Soil Science Society. Houston, Texas. November 28 - December 3.

VEGETATION AND SOIL MOISTURE

Title: Evaluation of cover production, herbage yield, and soil conditions for different levels of vegetation management

Personnel Involved:

G. A. Schumaker, Soil Scientist	Plan, design, and coordinate research activities and prepare reports.
C. L. Hanson, Agricultural Engineer	Perform computer analysis relative to soil moisture data and assist in analyzing field data.
D. L. Coon, Hydrologic Technician	Responsible for various aspects of data collection and field observations, including soil moisture measurement and calibration.

Date of Initiation: May 1971

Expected Termination Date: Continuing

INTRODUCTION

Quantitative data on herbage yield from rangelands under different levels of management are needed to guide land managers in coordinated multiple use of the range. These needs require more discerning information on how vegetation and soils respond to imposed treatments, including controlled grazing. Information is also needed with regard to methods of increasing cover and to the rate of recovery of native range following intensive practices.

Objectives:

Reynolds Creek

1. To determine the effects of grazing management and treatments on yield of herbage, cover production, soil moisture regime, and soil surface conditions at selected sites.

2. To study changes in plant density and plant composition as a result of grazing management and treatments.

Soils and vegetation studies were initiated on the Boise Front in late 1977. Objectives and Progress in these studies are discussed in a separate section.

PROGRESS

Reynolds Creek

Effects of grazing and nongrazing treatments:

Comparison of grazing and withholding grazing has been underway at eight study sites since 1970, Figure 1, when most of the exclosures were installed at Reynolds Creek. A continuous record of yields is available from all sites since 1974. For a description of these sites, see Table 1. Average yields for sites and treatment averages are shown in Table 2. The data were analyzed statistically and treatment means of eight sites were statistically different at the .05 level. Total vegetation yields from the ungrazed treatment were 9 percent less than grazed yields, while nonsage yields from the untreated plot were 17 percent less than grazed. In most cases, the difference in yield between grazed and ungrazed at the individual sites was not large; the only exceptions being at the Upper Sheep Creek and the Reynolds Mountain dense sites.

The overstory cover summarized from line transects taken in 1976 at the period of maximum growth is shown in Table 3. Cover varied from site to site, but was quite similar in composition between grazed and nongrazed treatments. It is well to point out that cover measurements represent the total vegetation, including the woody portion of brush species.

After cattle had been moved out of the pastures, where the study sites are located, BLM personnel made an estimate of 1976 animal utilization of the area. Utilization figures for six of the eight study sites are given in Table 4. Grazing was heavy or severe on all the pastures examined. The Reynolds Mountain pasture probably received moderate grazing, although no observations were made.

Soil water measurements were taken at six of the eight study sites during the growing season in order to determine whether water use was different where cattle were withheld from grazing. A comparison of water contents for the two treatments at two of the study sites is shown in Figure 2. The data does not show any difference in water use during the growing season to a depth of 2 feet; however, the ungrazed Nancy Gulch site retained more water due to soil profile differences and was consistently higher in water content throughout the period of measurement.

Table 1. Tabulation of site information

Site	ELE. (feet)	SLOPE (percent)	ASPECT OF SLOPE	PRECIP. (inches)	VEGETATIVE COVER (percent)	SCS HYDRO. CLASS.
			SPARSE VEGETATION SITES			
Flats	4000	5	N	10	25	B
Nancy Gulch	4600	8	NE	13	25	C
Lower Sheep Creek	5400	16	NW	14	25	B
Upper Sheep Creek	6100	25	SW	20 1/	25	D
Reynolds Mountain West	6850	5	SW	43 1/	25	B
			DENSE VEGETATION SITES			
Reynolds Mountain East	6800	6	NW	43 2/	50	B
Upper Sheep Creek	6100	33	NE	20 2/	50	C
Whiskey Hill	5500	15	E	14	50	B

1/ Snow removed by wind

2/ Snow deposition zone

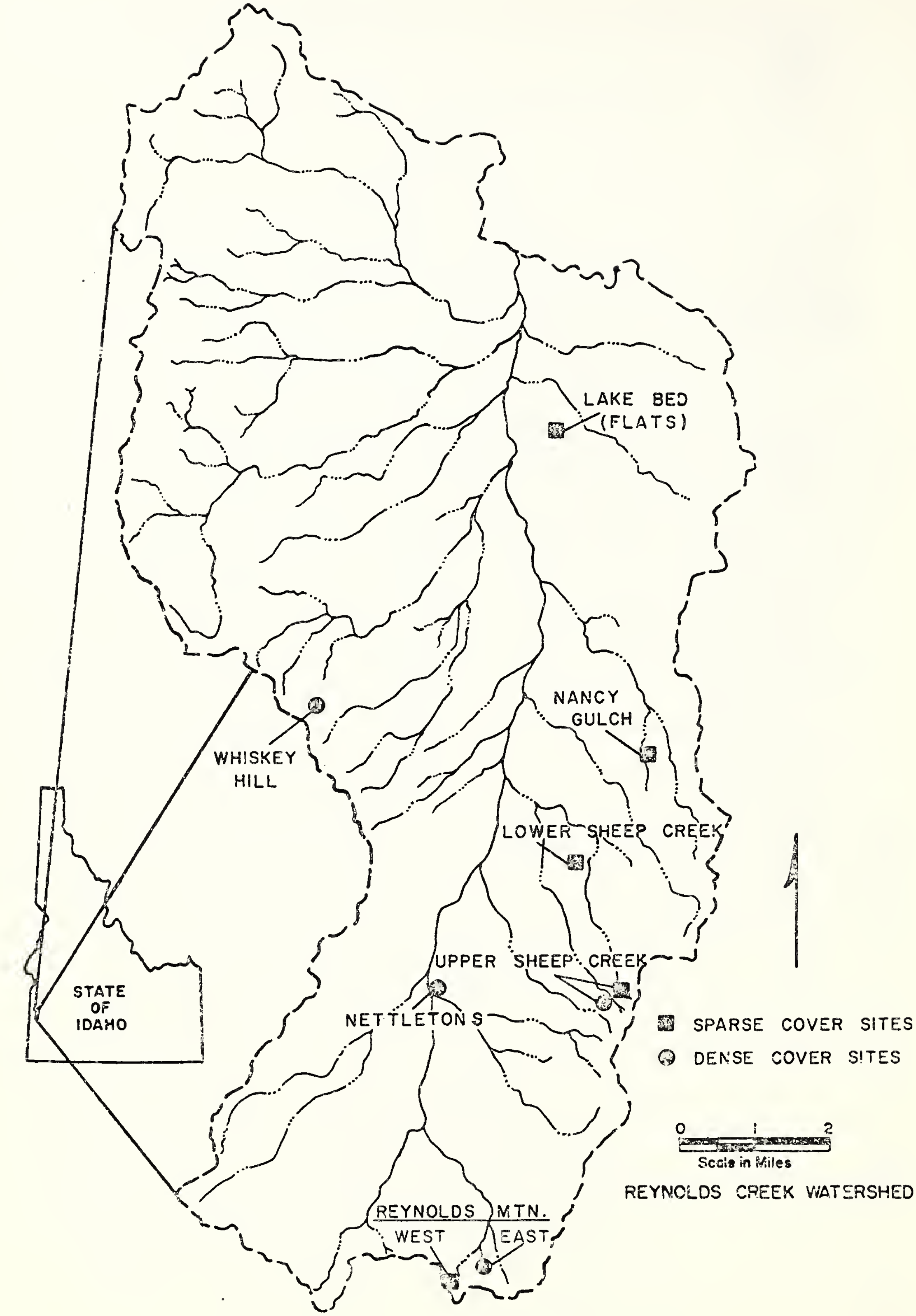


Figure 1. Location of study sites.

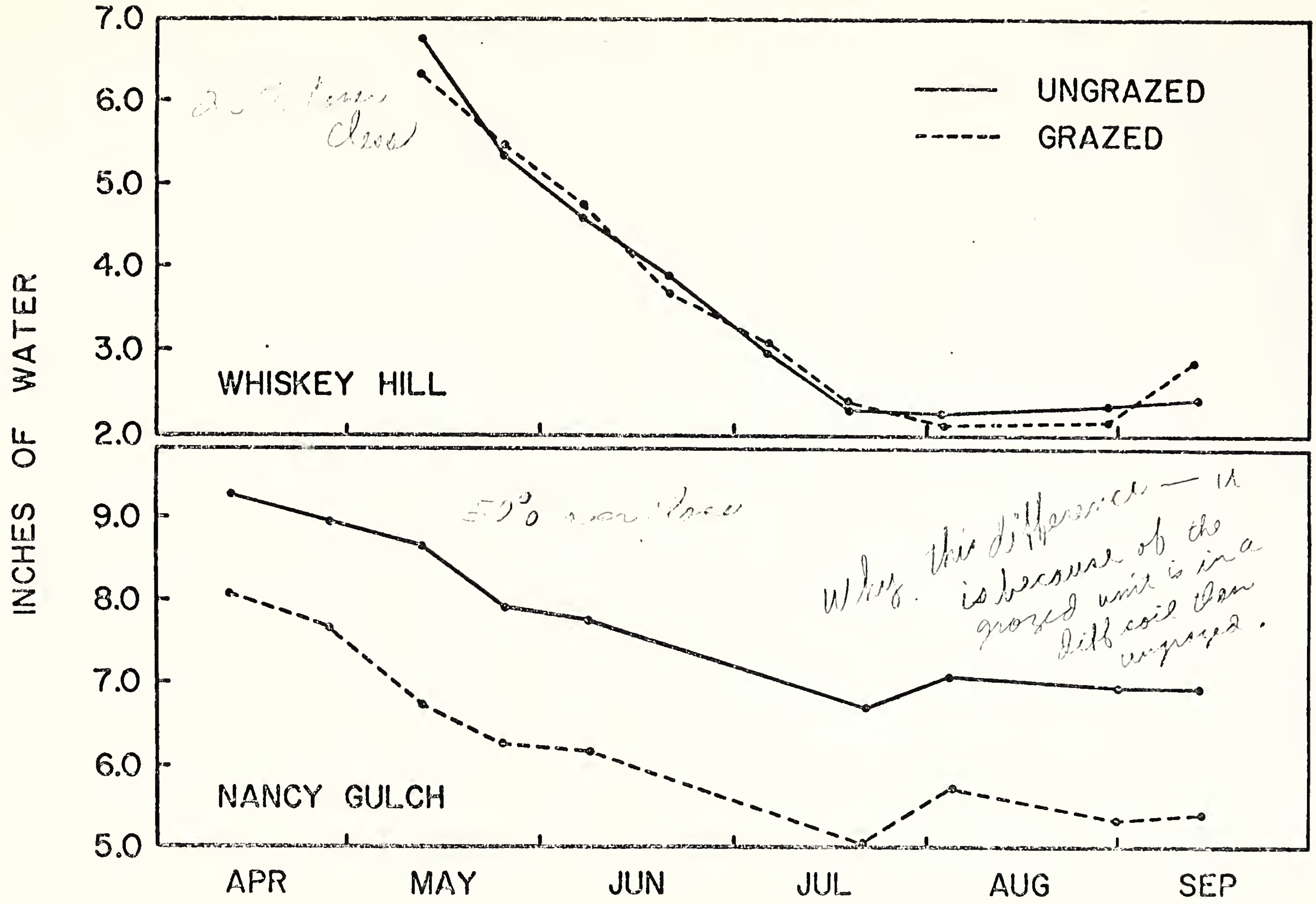


Figure 2. Water content during the growing season at two study sites having grazed and nongrazed treatments.

Table 2. Total yields and nonsage yields from eight study sites at Reynolds Creek, 1974 through 1976 averages

Site	TOTAL YIELD Untreated lb/acre	TOTAL YIELD Grazed lb/acre	NONSAGE YIELD Untreated lb/acre	NONSAGE YIELD Grazed lb/acre
Flats	463	499	360	413
Nancy Gulch	665	596	400	450
Whiskey Hill	927	997	726	598
Lower Sheep	528	574	301	336
Upper Sheep (Sparse)	351	480	211	340
Upper Sheep (Dense)	1061	1223	492	747
Reynolds Mtn. (Sparse)	584	604	362	388
Reynolds Mtn. (Dense)	1070	1256	441	678
Average	706	779	411	494

Effects of intensive grazing at the Nettleton site:

Cattle were turned into the grazed portion of the Nettleton study beginning on June 7, and were taken out 18 days later. Grazing began a week later than is normally planned and the bluegrass *(Poa sandbergii)* was fully headed. Total yields from the grazed and nongrazed treatments were 777 and 805 pounds/acre, respectively; while nonsage yields were 672 and 731 pounds/acre, respectively. Vegetative cover was 80 percent overstory from grazed and 85 percent from nongrazed. The effects of continuous grazing since 1970 were not as pronounced in 1976 as in the previous year, and forage produced from the ungrazed treatment was considerably less than in 1975. If it is assumed that all the nonsage plant material was available for animal consumption, then the 6.33 acres under grazing provided 4254 pounds of forage. The usual requirement for an animal is 750 pounds for a 30-day period or 450 pounds of forage for 18 days. Then the eight head using the area would require 3600 pounds of feed. All of the 4254 pounds per acre would not be available for consumption since trampling would occur. While the cattle were not weighed prior to and following grazing, based on appearance, the forage did not maintain animal weight during the grazing period. The cattle were kept in the study area until the whole area had been subjected to severe grazing.

TABLE 3. Cover measurements from eight study sites at Reynolds Creek

SITE		% VEGETATION	% LITTER	% ROCK	% BARE GROUND	
Flats	Ungrazed	66.5	11.9	1.7	20.0	100.1
	Grazed	60.3	8.0	6.7	24.9	99.9
Nancy Gulch	Ungrazed	60.4	8.3	11.1	9.9	
	Grazed	67.5	11.4	10.4	10.6	
Whiskey Hill	Ungrazed	78.8	14.0	1.4	5.9	
	Grazed	81.0	16.9	1.6	6.9	
Lower Sheep	Ungrazed	76.3	7.3	13.3	3.1	
	Grazed	78.7	7.6	11.3	2.4	
Upper Sheep (Sparse)	Ungrazed	57.0	11.0	19.0	13.4	
	Grazed	49.2	13.9	26.0	11.0	
Upper Sheep (Dense)	Ungrazed	89.0	9.4	0	1.6	
	Grazed	77.4	16	.4	6.2	
Reynolds Mtn. (W)	Ungrazed	64.0	6.9	20.7	8.4	
	Grazed	75.4	4.3	17.4	2.3	
Reynolds Mtn. (E)	Ungrazed	95.1	3.8	0	1.3	
	Grazed	89.6	7.6	.8	2.0	

Table 4. Utilization of key plant species during 1976 in BLM pastures having ARS study sites

Site	UTILIZATION Percent	Rating
Flats	60-80	Heavy
Nancy Gulch	80-100	Severe
Whiskey Hill	70-90	Heavy to Severe
Lower Sheep Creek	80-100	Severe
Upper Sheep Creek (Sparse)	80-100	Severe
Upper Sheep Creek (Dense)	80-100	Severe

Plant Adaptability Nurseries:

Evaluation of species adaptability continued in 1976 at the three nursery sites of trials established in the fall of 1974 at the Flats, Nancy Gulch, and Reynolds Mountain. The U.S. Forest Service is cooperating in this study.

Growing season precipitation was below normal at all three sites (Table 5). Amounts were 1.00, .24, and .71 inches below normal at Flats, Nancy Gulch, and Reynolds Mountain, respectively. Precipitation was less than normal for April at the Flats and Nancy Gulch sites when new growth on the nurseries was beginning. At Reynolds Mountain, melting snow provided adequate moisture through most of May and moisture during the remaining months of the growing season was near normal.

Table 5. Growing season precipitation at nursery sites, 1976, and 1968-1976 average.

	FLATS In.	NANCY In.	REYNOLDS MTN. In.
April 1976	.38	.63	--
'68-76 Av.	.80	1.02	--
May 1976	.42	.62	.98
'68-76 Av.	.41	.49	1.60
June 1976	.72	.88	2.11
'68-76 Av.	1.20	1.18	2.20
July 1976	.62	.82	.71
'68-76 Av.	.30	.35	.72
August 1976	.72	1.22	1.25
'68-76 Av.	.77	.74	1.24
Season Total 1976	2.48	3.54	5.05
'68-76 Av.	3.48	3.78	5.76

A rating of fair, good, or excellent is given to those plantings that appear most promising, Table 6. While stands of some other plantings were still present, they lacked vigor and were not given a rating.

At the Flats, the low precipitation site, Nordan Crested Wheatgrass *(Agropyron desertorum)* continues to show promise as well as the Amur selection of intermediate wheatgrass *(Agropyron intermedium)*. The

Table 6. Ratings of Reynolds Creek Plantings - 1976

			Area of Adaptation		
Symbol	Scientific Name	Source	Flats	Nancy Gulch	Reynolds Mtn.
Grasses					
AGCR x	*Agropyrcn cristatum* x	Logan ARS	2[1/]	2	2
AGDE B1-68	*A. desertorum*				
AGCRF B9-70 (B10-65)	*A. cristatum fairway*	Colorado (Commercial)			2
AGCR B9-70	*A. cristatum fairway*	Colorado			2
AGDA x	*A. dasystachyum* x	Logan ARS			2
AGCA B1-69	*A. caespitosum*				
AGDE B2-68	*A. desertorum*	Montana (Nordan)	3	3	2
AGEL B5-69	*A. elongatum*	Commercial	2	2	1
AGIN B4-68	*A. intermedium*	Wyoming (Oahe)		3	3
AGIN B5-68	*A. intermedium*	Washington (Greenar)		3	3
AGIN B6-68	*A. intermedium*	Commercial (Amur)	2	3	3
AGIN B13-70	*A. intermedium*	Commercial (Tegmar)		3	3
AGJU B3-74	*A. junceum*	France PI276566			3
AGRE x	*A. repens* x				3
AGDE	*A. desertorum*				
AGRI B1-69	*A. riparium*	Commercial (Sodar)	2	2	2
AGSI B1-68	*A. sibiricum*	Idaho	3	3	2
AGSM B1-68	*A. smithii*		2		1
AGTR B5-68	*A. trachycaulum*	Montana (Commercial)			3
AGTR[2] B2-68	*A. trichophorum*	Colorado (Luna)	2	3	3
AGTR[2] B3-68	*A. trichophorum*	Idaho (Topar)	2	2	3
ALPR B4-69	*Alopechrus pratensis*	Commercial			3
BRBI B1-66	*Bromus biebersteinii*				3
BRCA B4-74	*B. carinatus*	Leadville, Colorado			3

1/ Numeric ratings are 1, Fair; 2, Good; and 3, Excellent.

Table 6. Ratings of Reynolds Creek Plantings - 1976 (Continued)

Symbol	Scientific Name	Source	Area of Adaptation: Flats	Nancy Gulch	Reynolds Mtn.
BRIN B6-74	*B. inermis*	U.S.S.R. PI315374			3
BRIN B7-74	*B. inermis*	U.S.S.R. PI315378			3
BRIN B13-70	*B. inermis*		2		
BRIN B19-74	*B. inermis*	GBRS (Northern)		3	3
BRIN B22-67	*B. inermis*	Commercial (Manchar)			3
BRIN B9-69	*B. inermis*	Commercial (Lincoln)			3
BRMA B6-69	*B. marginatus*	Pullman SCS (Bromar)			3
BRTO B6-66	*B. tomentellus*	SCS			2
CAEP B2-68	*Calamagrostis epigeios*	Commercial			3
DAGL B16-68	*Dactylis glomerata*	Yugoslavia PI251112		2	3
DAGL B17-65	*D. glomerata*	Ephraim dry land form	2	2	3
DAGL B24-65	*D. glomerata*	Yugoslavia PI251112		2	
DAGLH B2-74	*D. glomerata*	Australia PI209888			3
ELCI B8-72	*Elymuc cinereus*	East Boise			2
ELJU B9-61	*Elymus junceus*	Tetonia, Idaho		1	
FEAR[3] B3-68	*Festuca arundinacea*	Commercial (Fawn)			3
FEOVD B3-70	*Festuca ovina duriuscula*	Idaho (Doran)		2	3
FEOVSU B3-66	*F. ovina*	PI229450		2	2
PHPR B7-74	*Phleum pratense*	Missouri		2	3
POCO B4-69	*Poa compressa*	Northrup King			2
POPR B12-69	*P. pratensis*	Commercial		2	2
SEMO B5-62	*Secale montanum*	Pullman SCS		2	2
STVI B2-68	*Stipa viridula*	Montana (Commercial)			3
Forbs					
ACMIL B8-74	*Achillea millefolium lanulosa*	Reynolds Cr.			3
BAMA B1-69	*Balsamorhiza macrophylla*	Cache Co., Utah			2

Table 6. Ratings of Reynolds Creek Plantings - 1976 (Continued)

Symbol	Scientific Name	Source	Area of Adaptation		
			Flats	Nancy Gulch	Reynolds Mtn.
BASA B9-72	*B. sagittata*	Coeur d'Alene, ID			2
COVA B3-67	*Coronilla varia*	Nebraska (Pingifit)			3
COVA B4-67	*C. varia*	Commercial (Emerald)			2
ERUM B5-74	*Eriogonum umbellatum*	Grimes Cr., ID			2
HEBOU B6-69	*Hedysarum boreale utahensis*	R. Stewart			1
LILE B3-70	*Linum lewisii*	Snow College Farm	3	3	3
LOCO[3] B5-68	*Lotus corniculatus*	Vermont (Broadleaf)			2
LOCO[3] B6-68	*Lotus corniculatus*	California (Narrowleaf)			1
LOCO[3] B7-68	*L. corniculatus*	Canada (Empire)			3
LOCO[3] B8-59	*L. corniculatus*	Iowa			2
MEOF B1-69	*Melilotus officinalis*	Montana		2	2
MESA B9-69	*Medicago sativa*	Idaho (Rhizoma)		2	2
MESA B10-69	*M. sativa*	Idaho (Nomad)		2	2
MESA B11-69	*M. sativa*	Idaho (Ladak)		2	3
MESA B13-70	*M. sativa*	Commercial (Rambler)		1	3
MESA B32-66	*M. sativa*	S. Dakota		1	2
MESA B61-74	*M. sativa*	Commercial			2
ONVI B10-69	*Onobrychis viciaefolia*	Montana (Eski)			2
SAMI B10-70	*Sanguisorba minor*	NK Oregon Commercial		2	3
SOGI B1-74	*Solidago gigantea*	Reynolds Creek			3
VIVI B1-60	*Vicia villosa*	Major's Flat, UT			2
Shrubs					
ACGL[2] B3-74	*Acer glabrum douglasii*	Reynolds Creek			1
AMAL B10-74	*Amelanchier alnifolia*	Bonneville Co., Idaho			3
AMUT B1-67	*A. utahensis*	Henryville, UT			1

Table 6. Ratings of Reynolds Creek Plantings - 1976 (Continued)

			Area of Adaptation		
Symbol	Scientific Name	Source	Flats	Nancy Gulch	Reynolds Mtn.
ARTRV B3-74	*Artemesia tridentata vaseyana*	Reynolds Creek			2
ATCO B3-74	*Atriplex confertifolia*		1		
CEVE B9-74	*Ceanothus velutinous*	Reynolds Creek			2
CELA B5-74	*Ceratoides lanata*	Reynolds Creek	2		
CHNA B17-74	*Chrysothamnus nauseosus*	Reynolds Creek		1	
COMES B3-70	*Cowania mexicana stansburiana*	American Fork, UT		2	1
EPNE B3-71	*Ephedra nevadensis*	Pine Valley, UT	1	1	
PREM B4-74	*Prunus emarginata*	Reynolds Creek			1
PUTR B1-69	*Purshia tridentata*	Moffet Co., Colorado		2	2
PUTR B2-69	*P. tridentata*	Fremont Co., ID			2
PUTR B5-72	*P. tridentata*	Boise		1	3
PUTR B21-63	*P. tridentata*	Eureka, UT			2
PUTR B24-67	*P. tridentata*	Mono Lake, Calif.			2
PUTR B36-73	*P. tridentata*	Washoe Co., Nev.		1	
ROWO B17-74	*Rosa woodsii*	Reynolds Cr.			3
SYOR B1-69	*Symphoricarpus oreophilus*	Bear Lake, UT			2
SYOR B13-74	*S. oreophilus*	Reynolds Cr.			2

Sodar selection of streambank wheatgrass *(Agropyron riparium)* also was given a good rating. The Lena and Topar selections of pubescent wheatgrass *(Agropyron trichophorum)* show promise. Smooth brome *(Bromus inermus)*, not usually suitable for areas with such low precipitation, will continue to be observed. The Agropyron cristatum x A. desertorum hybrid from Logan, Utah, is promising.

Very few forbs have shown vigor at the Flats site, but Lewis flax *(Linum lewisii)* has promise both with regard to emergence and vigor, although precipitation averages 10 inches annually. Lewis flax has other desirable features; it is palatable to livestock and yet it is not consumed by rabbits. While small burnet *(Sanguisorba minor)* was not planted at the Flats; its adaptation is much like Lewis flax and, therefore, would be expected to perform well.

Stands of the arid shrub fourwing saltbrush *(Atriplex confertifolia)* were obtained at the Flats from local seed collections. Also, the local seed source of winterfat *(Ceritoides lanata)* looks very promising for the arid site.

The list of forbs and grasses that perform well at the Nancy Gulch and Reynolds Mountain sites is quite numerous. Selections of pubescent wheatgrass, intermediate wheatgrass, smooth brome, and orchard grass *(Dactylis glomerata)* would be recommended for these sites. The Yugoslavia selection of orchard grass continues to look promising at the Nancy Gulch site. Seed was not available for planting elsewhere. The DAGL B17-65 selection of orchard grass has performed well at all three sites and bears observation over the long term. Originally, this selection was tested under irrigation at Tucson, Arizona, and while it was tolerant to warm temperatures, it did not have the regrowth characteristics desired for irrigated pastures. In Forest Service tests it demonstrated its drought tolerance and continues to show promise in the Reynolds Creek tests, even in the Flats area. The fescue plantings have done well, but the hard sheep fescue *(Festuca ovina duriuscula)* shows a wider range of adaptability than sheep fescue *(Festuca arundinacea)*; however, observation of both of these species should continue. Mountain rye *(Secale montanum)* was rated good and bears continued observation.

Several succulents and broadleaf forbs are worthy of consideration for planting where climatic conditions are similar to Nancy Gulch and Reynolds Mountain. The best performing plants were the rangeland types of alfalfa *(Medicago sativa)*. There is no indication that one selection is better than the other, but are adapted throughout the range of climatic conditions from Nancy Gulch to Reynolds Mountain.

The root-spreading type, MESA B9-69, was included in the plantings and it may be the most persistent in areas of deep snow, where rodents are a problem, such as at Reynolds Mountain.

Crown vetch *(Coronilla varia)* is not attacked by rodents and is, therefore, worthy of consideration. Birdsfoot deervetch *(Lotus corniculatus)* selections have been slow in getting established at Reynolds Mountain, but should produce well in future years at this site. Hairy vetch *(Vicia villosa)* has also been slow to become established and this may be an instance where the proper innoculum is needed.

Shrubs have performed well at the Reynolds Mountain site; some have features that are worth noting. The Woods rose *(Rosa woodsii)*, Reynolds Creek selection, and snowberry *(Symphoricarpus oreophilus)*, also from Reynolds Creek, gave excellent germination. Ordinarily, seeds from these two species are quite dormant. Present indication is that seeds selected from Reynolds Creek germinate much easier. Another feature of this selection of rose is its rapid growth.

The Moffet County, Colorado selection of bitterbrush *(Purshia tridentata)* has proven to be adaptable to acid soil sites, although collected on calcareous soils. It has good seedling vigor and is one of the best seed sources available. In addition to providing browse for big game, bitterbrush provides excellent erosion control.

Objectives:

Boise Front

1. To determine the effects of a rest-rotation grazing and deer management system on vegetative composition and cover.

2. To investigate changes in soil physical properties as influenced by a grazing system.

Resource Data:

The study area is located in the foothills of the Boise Mountains. These foothills are quite steep and range in elevation from 3,000 to 5,900 feet. A soil survey has been completed and publication will be available at a future date.

There are numerous canyons that cross the study area and drain into the Boise River. Generally, the slope and exposure are to the south-southwest.

Vegetation[1/]

Big sagebrush dominates the vegetation; however, there are numerous small vegetative types throughout the allotment.

1/ Information taken from Boise Front, Allotment Management Plan, Boise Front Planning Unit, Boise District, Bureau of Land Management.

The ground cover averages 28 percent in the sagebrush vegetative type with annual grasses and forbs averaging 50 percent of the species composition by density.

At the lower elevations with southern exposures, the grass species consist of red threeawn *(Aristida longiseta)*, cheatgrass *(Bromus tectorum)*, medusa *(Taeniatherum asperum)*, Sandbergs bluegrass *(Poa sandbergii)*, and bottlebrush squirreltail *(Sitanion hystrix)*. Big sagebrush *(Artemisia tridentata)* and bitterbrush *(Purshia tridentata)* densities vary from site to site depending on how recent the area has been burned.

On the northern exposures at the same elevations, bluebunch wheatgrass *(Agropyron spicatum)*, Idaho fescue *(Festuca idahoensis)*, Thurber needlegrass *(Stipa thurberiana)*, sagebrush and bitterbrush *(Purshia tridentata)* are found in fairly dense stands.

As the elevation increases, more of these species can be found on the southern exposures. Brush cover on the northern slopes increases and the species composition changes to include chokecherry *(Prunus virginiana)*, bittercherry *(Prunus emarginata)*, buckbrush *(Ceanothus spp.)* and willows *(Salix spp.)*. At the higher elevations, Douglas fir *(Pseudotsuga menziesii)* becomes quite dense. Open areas contain willows, some ponderosa pine *(Pinus ponderosa)*, Aspen *(Populus tremuloides)*, serviceberry *(Amelanchier alnifolia)*, buckbrush and cherry.

Rubber rabbitbrush *(Chrysothamnus nauseosus)* is found scattered over the allotment.

Riparian vegetation, which includes willows, dogwoods, poison ivy, hawthorne, etc., can be found along all the major drainages. In 1959, a wildfire and two destructive floods coming from the Boise Front resulted in 2,820 acres reseeded to various wheatgrasses and browse species. These seedings were quite successful.

Grazing treatment schedules:

License-holders for the Boise Front Allotment Management Plan allow their cattle to graze under guidelines determined jointly by the grantors of licenses who determine range readiness in the spring and, in turn, establish the spring turnout date.

Grazing treatments are as follows:

1. Graze seasonlong for livestock production and hedging of browse for the development of desirable form classes on browse.

2. Rest seasonlong for plant vigor and leader growth.

3. Rest until seed ripe, graze thereafter for seed trampling and dissemination.

4. Rest seasonlong for seedling establishment.

The schedule of the rest-rotation grazing system is given in Table 7.

The pastures are divided according to elevation (low 1 high 1, etc.), Introduction Figure 1. Since the elevation changes rapidly, the lower pastures are ready to be grazed, based on range readiness and plant growth requirements, while the higher elevation pastures are several weeks behind in range readiness. (Range readiness is based on physiological growth requirements of the forage species and the classes of livestock.) The system provides for rest during the critical growing periods, allows for the desirable forage species to reproduce and new seedlings a chance to become established. The same range readiness criteria is used in determining turn-out into the High Pastures.

Procedure for evaluation of effects of rest rotation:

Vegetation

Non-Browse

1. Establish sites for intensive vegetation study, which are representative of Boise Front soils and vegetation types.

    a. Install fenced exclosures at study sites for comparing areas grazed by cattle with ungrazed areas.

    b. Select sites adjacent to fence lines and compare vegetation on areas under rotation grazing and those with a long history of nonuse.

2. Species composition and cover will be measured, using methods given by Hyder, et al.[2/] The method consists

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2/ Hyder, D. N., et al., Ecological responses of native plants and guidelines for management of shortgrass range. USDA Technical Bulletin No. 1503. May 1975.

Table 7. Grazing schedule and type of management for Boise Front Pastures

YEAR	PASTURE NAME			
	H or L, 1[1/]	H or L, 2	H or L, 3	H or L, 4
1977	B Rest Season Long (for Plant Vigor)	D Rest Season Long (Seedling establishment)	C Early Rest (until Seed Ripe)	A Graze Season Long
1978	C Early Rest (until Seed Ripe)	A Graze Season Long	D Rest Season Long (Seedling establishment)	B Rest Season Long (for Plant Vigor)
1979	D Rest Season Long (Seedling establishment)	B Rest Season Long	A Graze Season Long	C Early Rest (until Seed Ripe)
1980	A Graze Season Long	C Early Rest (until Seed Ripe)	B Rest Season Long (for Plant Vigor)	D Rest Season Long (Seedling establishment)

1/ H, 1 or L, 1 refers to High Pasture 1 or Low Pasture 1, etc.

of establishing transect lines and noting plant species and cover within a 1-ft^2 quadrant at 10-feet intervals along the transect line. Data will be taken from 20 lines in the exclosure and from 20 lines in the adjacent area.

3. Measurement of seedling vigor.

   a. Data will be taken at study sites.

   b. One hundred emerging seedlings of bottlebrush squirreltail *(Sitanion hystrix)* will be identified and permanently marked during the spring.

   c. Readings for survival will be taken in the fall following establishment and one year after establishment.

   c. New sets of seedlings will be identified and marked annually during the period of study.

Browse

1. Data will be taken on bitterbrush *(Prushia tridentata)* following winter use by deer and following summer use by cattle. The method employed will be the Cole form class technique and will provide an estimate of use and vigor of bitterbrush.

   a. Permanent transects will be identified at two locations in the low pastures and at one location in each of the high pastures.

   b. Leaders on bitterbrush plants occurring on the transect line will be examined for evidence of browse. An occular estimate of percentage of use will be given to each shrub.

   c. For an expression of plant vigor, the average length of unbrowsed leaders will be estimated for each shrub in the transect.

2. Quantitative measurements on bitterbrush.

   a. A limited number of leaders on bitterbrush will be marked for fall and spring linear measurement.

   b. At the time of repeat measurement, the tagged leaders will be identified as showing browse or not.

Soil physical condition

The need to evaluate the effect of rotation grazing on soil physical condition is recognized. A rainfall infiltrometer survey may be made at the end of a 4-year rotation cycle.

PROGRESS

Boise Front

Vegetation:

Non-Browse

Four study sites have been identified (Figure 1); one site is located in pasture H1, two are located in pasture L2, and one is located in pasture L3. Exclosures were constructed at the two L2 sites in the fall of 1976. The exclosure on pasture H1 will be constructed in the spring of 1977, prior to measuring species composition. Areas for data collection in pasture L3 will be marked in the spring of 1977. Measurement of seedling vigor will be at the study sites shown in Figure 1; seedlings will be identified in the spring of 1977.

Browse

Permanent line transects were established on bitterbrush and readings were taken in the fall of 1976. The transects will be read again in the spring and fall of 1977.

Soil physical condition:

No plans.

WORK PLAN FOR 1977

Reynolds Creek

1. Measurement of changes in species composition, cover, herbage yield, and soil surface condition will be continued.

2. Water use measurements under grazed and nongrazed treatments will be continued.

3. Collect data on the adaptability of various species of grasses, forbs, and shrubs and prepare an interim report.

Boise Front

1. Collect and analyze data from four study sites on the Boise Front.

REPORTS AND PUBLICATIONS

Schumaker, Gilbert A. and Clayton L. Hanson. 1976
Herbage response after mechanical and chemical treatment of big sagebrush in southwest Idaho. Accepted for publication as WR series report.

Hanson, Clayton L., Gilbert A. Schumaker, and Carl J. Erickson. 1976
Influence of fertilization and supplemental runoff water on production and nitrogen content of western wheatgrass and smooth brome. Journal of Range Management 29(5): 406-409.

Gift

DATE: 1-30-81

TEMPORARY ENTRY

NO.

Reynolds Creek Watershed : ARS-BLM Cooperative Studies. / principal investigator C. L. Hanson (et. al.) Boise, Idaho : U.S. Dept. of Agriculture, Agricultural Research, Northwest Watershed Research Center...1977.
78 p. (Interim Report No. 7)

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USDA-NAL
RESOURCE DEVELOPMENT

LF-324
(8-73)

EVAPOTRANSPIRATION

Title: Natural evaporation from sagebrush rangelands, alfalfa, and stockponds in a semiarid environment

Personnel Involved:

C. L. Hanson, Agricultural Engineer	Supervises the planning and design of evaporation studies. Performs analyses and reports results.
D. L. Coon, Hydrologic Technician	Assist in the planning, designing, execution; including soil water measurement and calibration, analyzing, and reporting results.
M. D. Burgess, Electronic Technician	Designs, constructs, and services electronic sensors and recording system.

Date of Initiation: November 1968

Expected Termination Date: Continuing

INTRODUCTION

The evapotranspiration component for soil vegetation complexes must be understood so that changes in levels of rangeland management can be hydrologically evaluated. The Northwest Watershed Research Center is conducting evapotranspiration studies designed for measuring and predicting evapotranspiration under sparse vegetative cover and unsaturated surfaces.

Objectives:

1. To measure the evaporative loss of water from sagebrush rangelands, irrigated alfalfa, and stockponds, and observe pertinent meteorological parameters and the soil water status.

2. To develop, for predictive purposes, relationships for associating the evaporative loss with meteorological parameters, type and degree of surface cover, soil water, and potential evaporative demand.

PROGRESS

Reynolds Creek

The primary emphasis was on hydrologic modeling. In the USDAHL-74 revised model of watershed hydrology (Holtan, Stiltner, Henson, and Lopez, 1975), the evapotranspiration (ET) routine requires average weekly air temperature and average weekly Class A pan evaporation. The air temperatures were obtained from local data, but pan evaporation was estimated from a pan at Parma, Idaho, as pan evaporation data available are only for summer months. Winter pan evaporation had to be estimated from temperature data.

A comparison between the measured and simulated soil water was used to determine how well the evapotranspiration section of the model predicted water use. It appeared that the model did not evaporate enough water during the cool or cold months and evaporated excessive water during the early, warm period of the year. However, after adjusting some of the parameters in the model, the model simulated soil water adequately with the exception of late summer and early fall. This problem in the model is probably because it was originally written for agricultural crops, which do not use soil water during the cold season and for regions that have most, or at least a considerable part, of the annual precipitation during the growing season. Some, or all, of the vegetation species on the Summit Basin may grow any time there is water available and the daytime temperature is warm enough for growth. This growth pattern is not characterized by the model input of mean weekly temperatures and average weekly Class A pan evaporation. The evaluation of the model indicated that the ratio between evapotranspiration and pan evaporation was a very sensitive parameter.

Two lysimeters at the Lower Sheep Creek site were in operation from mid-April through mid-October 1976. The daily evapotranspiration rates from these lysimeters were about 0.09 inch per day during May, decreasing to very low rates during August when the soil became dry, and increased again in the fall after we had considerable September rain. The two lysimeters at Reynolds Mountain site were in operation from early May to the first week of October. The daily evapotranspiration rates from these lysimeters were about 0.16 inch per day from mid-June through July, and then decreased considerably in late summer. Evapotranspiration rate increased in mid-September following heavy rainfall.

Bi-weekly neutron soil water measurements were obtained in the lysimeters during the growing season. Soil water was also obtained on a bi-weekly basis from the regular soil water measuring locations on the experimental watershed.

Leaf area index (LAI) was measured periodically on the four lysimeters with results listed in Tables 1 and 2. LAI on the two Lower Sheep lysimeters reached a maximum of about 1.20 and .85 during May and early June, and then decreased until the last of August. LAI increased again in August and September after considerable rain. Grass LAI was highest in May, decreasing through August and then increasing with the considerable growth in September and October due to the heavy September precipitation. The total LAI values for 1976 are somewhat higher than they were in 1974.

Maximum LAI values on the Reynolds Mountain lysimeters were about 1.0 and 1.3 in July. The LAI values decreased to about 0.3 by mid-September. The higher LAI values on the south lysimeter were primarily due to more sage. These LAI values are almost the same as those obtained in 1975.

Boise Front

Soil water access tubes were installed at all of the rain gage sites except the site near the outlet of Maynard Gulch. This tube will be installed March 1977. (Introduction Figure 1). Soil water was observed bi-weekly, starting November 17, 1976.

SIGNIFICANT FINDINGS

After adjustment of some of the parameters, the USDAHL-74 revised model of watershed hydrology simulated soil water adequately with the exception of late summer and early fall.

WORK PLAN FOR FY 78

1. Continue operating the lysimeters at both the Lower Sheep Creek and Reynolds Mountain experimental sites for defining ET rates.

2. Continue the soil water measuring and data processing program.

3. Develop a rangeland ET model to use in a rangeland hydrologic model.

REPORTS AND PUBLICATIONS

Hanson, Clayton L. 1976
Model for predicting evapotranspiration from native rangelands in the northern Great Plains. Transactions of the ASAE 19(3): 471-477 and 181.

TABLE 1.--Leaf area index (LAI) on the lysimeters at Lower Sheep Creek study site, 1976.

Date	5/4	5/20	6/9	6/23	7/7	8/13	8/30	9/21	10/7
Vegetation									
	East Lysimeter								
Grasses	.45	.40	.17	.11	.05	.02	.01	.22	.27
Forbs	.12	.13	.07	.04	.02	0	0	0	0
Sagebrush	.19	.67	.78	.68	.51	.27	.19	.17	.12
TOTAL	.76	1.20	1.02	.83	.58	.29	.20	.39	.39
	West Lysimeter								
Grasses	.43	.25	.08	.07	.03	.01	0	.22	.31
Forbs	.03	.07	.02	.03	0	0	0	0	0
Sagebrush	.39	.51	.65	.73	.39	.18	.25	.19	.14
TOTAL	.85	.83	.75	.83	.42	.19	.25	.41	.45

TABLE 2.--Leaf area index (LAI) on the lysimeters at the Reynolds Mountain study site, 1976.

Date	5/20	6/9	6/23	7/7	8/13	8/30	9/14	10/18
Vegetation								
	North Lysimeter							
Grasses	.19	.25	.29	.34	.24	.14	.13	.05
Forbs	.07	.21	.21	.17	0	0	0	0
Sagebrush	.37	.45	.41	.54	.33	.40	.33	.23
TOTAL	.63	.91	.91	1.05	.57	.54	.46	.28
	South Lysimeter							
Grasses	.25	.40	.32	.34	.27	.15	.20	.06
Forbs	.15	.31	.22	.22	.03	.02	.01	0
Sagebrush	.37	.25	.50	.77	.51	.49	.39	.24
TOTAL	.77	.96	1.08	1.33	.81	.66	.60	.30

The Reynolds Creek Watershed offers an excellent opportunity to study water quality characteristics related to several of the above-mentioned problems. No commercial fertilizers have been used on the watershed. Herbicides were used infrequently for sagebrush control, but not since 1965. The only pesticide used on the watershed was a single application of malathion in July 1975 for grasshopper control.

With the present distribution of hydrologic networks throughout the watershed, sampling of both surface and subsurface flow for water quality analyses can easily be accomplished. The water quality constituents can be related to the hydrology of the system, particularly the properties of the water, the distribution, and the circulation.

The BLM has expressed need for more information on water quality changes influenced by various land management practices. As more rangeland is being used for recreation, this information becomes more important.

Objectives:

To determine water quality characteristics of the hydrologic flow regime of the Reynolds Creek Watershed as related to:

1. Concentrations of cattle on local areas of rangeland and quasi-feedlot conditions,

2. Irrigation return flow, and

3. Natural soil, geologic, and vegetative conditions.

PROGRESS

Reynolds Creek

The work plan for the year consisted of (1) reducing the chemical sampling network to two key sites for comparing chemical quality of streamflow from rangeland, and from irrigated crop and pastureland; (2) increase sampling frequency during major runoff events to determine changes in bacterial concentrations with streamflow; and (3) use of indicators from nonpoint sources of pollution on rangeland for comparison with water quality standards.

A total of 22 sites on Reynolds Creek and its tributaries were sampled for bacteria determinations and two sites for chemical determinations. Figure 1 gives the location of all sampling sites, and Table 1 gives the range of all water quality characteristics for all sampling sites, resulting from 1976 analyses. Discussion of the results follows.

WATER QUALITY

Title: Water quality characteristics of the hydrologic flow regime of the Reynolds Creek Experimental Watershed

Personnel Involved:

G. R. Stephenson, Geologist	Responsible for coordinating activities with cooperators. Design collection network and responsible for project completion.
J. F. Zuzel, Hydrologist	Responsible for statistical analysis of data and shares the responsibility for aquatic sampling.
J. H. Harris, Biological Technician	Responsible for collection of water samples and laboratory analyses.

Date of Initiation: October 1972

Expected Termination Date: Continuing

INTRODUCTION

In recent years, because of the increased concern for the quality of our environment, many agricultural practices have come under close scrutiny as potential sources of air and water pollution.

In light of P.L. 92-500, "Guidelines for identifying and evaluating the nature and extent of nonpoint source pollution" are needed. When determining pollution from agricultural land it becomes necessary to separate superimposed effects of different land use practices from natural variations in water quality.

Research is needed on the water quality characteristics of rangeland watersheds under natural conditions and under conditions imposed by changes in land use practices. Results from this research should be able to provide a link between downstream water quality and upstream activities and management practices. This information can then be used to determine if the management practices are consistent with downstream water quality objectives or state and/or federal water quality standards.

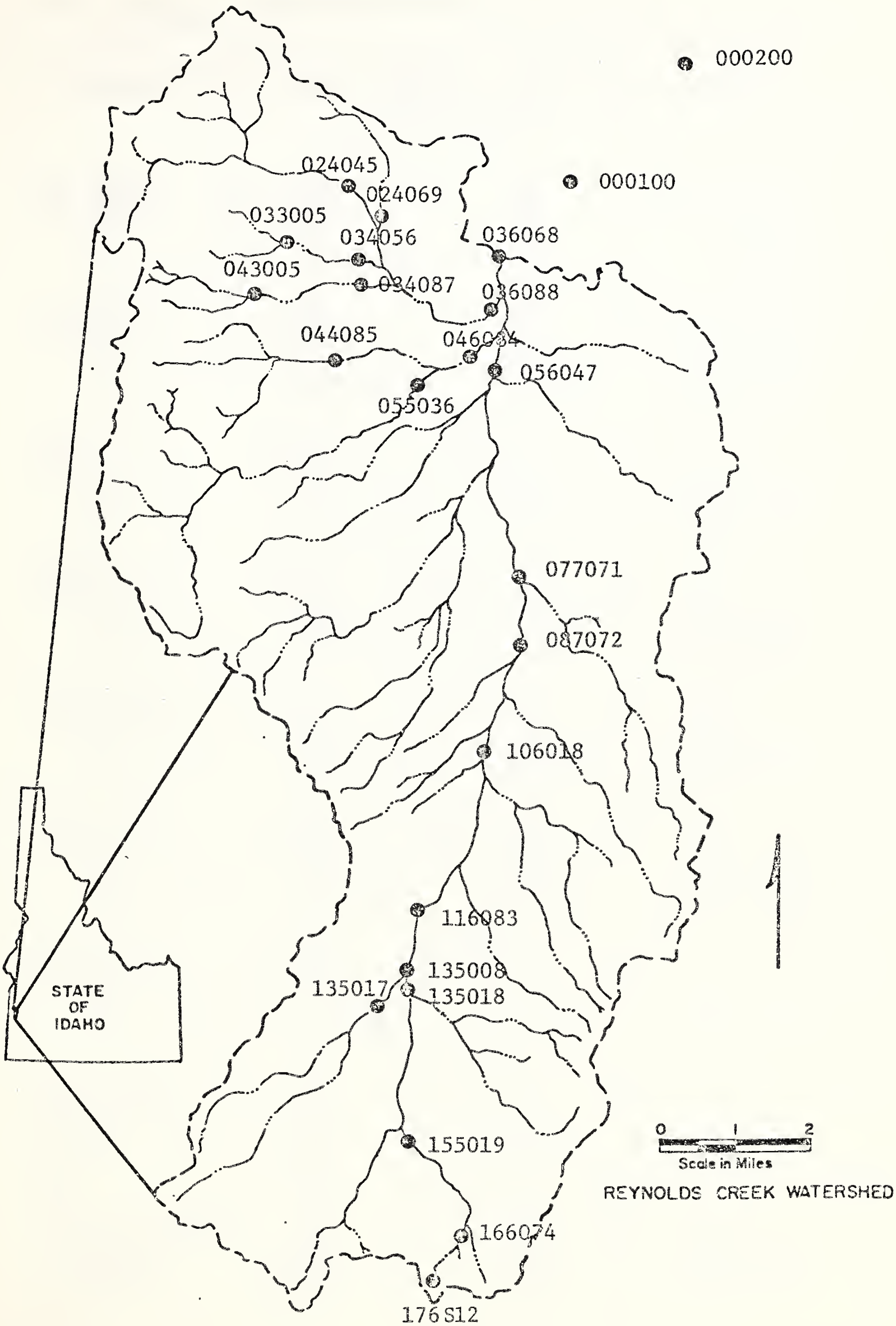

Figure 1. Location of water quality sampling sites, Reynolds Creek Watershed and adjacent area.

TABLE 1.--Water quality characteristics, Reynolds Creek Watershed sampling site

Parameter	Units	No. of Samples	Maximum	Minimum	Average
		LOWER REYNOLDS (036088)			
pH	units	9	8.70	7.30	8.20
Conductivity	µmhos	9	1185.00	281.00	663.00
Dissolved solids	mg/l	9	720.00	204.00	462.22
Calcium	mg/l	9	73.55	23.45	47.70
Magnesium	mg/l	9	28.93	11.06	18.60
Sodium	mg/l	9	157.93	26.21	81.61
Phosphorous	mg/l	9	0.30	0.02	0.13
Nitrate	mg/l	9	0.54	0.03	0.15
SiO_2	mg/l	9	44.30	29.60	34.87
Sodium Adsorption Ratio	ratio	9	4.62	1.12	2.42
Suspended solids	mg/l	9	56.50	1.00	20.06
Total coliform	cts/100 ml	31	550	10	177
Fecal coliform	cts/100 ml	31	395	0	92
Fecal strep	cts/100 ml	31	615	8	148
		SALMON CREEK (036088)			
Total coliform	cts/100 ml	31	1175	0	140
Fecal coliform	cts/100 ml	31	952	0	80
Fecal strep	cts/100 ml	30	316	4	96
		UPPER SALMON (024045)			
Total coliform	cts/100 ml	17	1020	20	222
Fecal coliform	cts/100 ml	17	968	0	118
Fecal strep	cts/100 ml	17	430	4	126
		BOSTON'S DITCH (024069)			
Total coliform	cts/100 ml	8	2880	0	661
Fecal coliform	cts/100 ml	8	1670	0	416
Fecal strep	cts/100 ml	8	320	4	153
		UPPER FARROT (033005)			
Total coliform	cts/100 ml	11	2230	4	635
Fecal coliform	cts/100 ml	11	1880	0	344
Fecal strep	cts/100 ml	11	600	0	180
		LOWER FARROT (034056)			
Total coliform	cts/100 ml	17	720	7	112
Fecal coliform	cts/100 ml	17	540	0	53
Fecal strep	cts/100 ml	17	545	4	129
		LOWER MURPHY (034087)			
Total coliform	cts/100 ml	17	345	0	123
Fecal coliform	cts/100 ml	17	198	0	52
Fecal strep	cts/100 ml	17	468	0	108
		UPPER MURPHY (043005)			
Total coliform	cts/100 ml	12	2570	0	638
Fecal coliform	cts/100 ml	12	2145	0	342
Fecal strep	cts/100 ml	12	925	2	181

TABLE 1.—Water quality characteristics, Reynolds Creek Watershed sampling site (Continued)

Parameter	Units	No. of Samples	Maximum	Minimum	Average
		COTTLE CREEK (044085)			
Total coliform	cts/100 ml	16	2360	0	501
Fecal coliform	cts/100 ml	16	1918	0	284
Fecal strep	cts/100 ml	16	350	4	122
		MACK'S CREEK WEIR (046084)			
Total coliform	cts/100 ml	31	1555	0	296
Fecal coliform	cts/100 ml	31	1200	0	128
Fecal strep	cts/100 ml	30	595	12	181
		UPPER MACK'S (055036)			
Total coliform	cts/100 ml	11	460	0	147
Fecal coliform	cts/100 ml	11	304	0	68
Fecal strep	cts/100 ml	11	348	4	173
		LOWER REYNOLDS (056047)			
Total coliform	cts/100 ml	32	880	20	288
Fecal coliform	cts/100 ml	32	795	0	115
Fecal strep	cts/100 ml	31	1540	0	271
		TYSON'S BRIDGE (077071)			
Total coliform	cts/100 ml	34	1000	5	261
Fecal coliform	cts/100 ml	34	412	0	100
Fecal strep	cts/100 ml	33	1015	0	234
		NETTLETON'S BRIDGE (087072)			
Total coliform	cts/100 ml	31	4630	10	627
Fecal coliform	cts/100 ml	32	1680	0	271
Fecal strep	cts/100 ml	31	1480	0	232
		GABICA (106018)			
Total coliform	cts/100 ml	32	608	5	109
Fecal coliform	cts/100 ml	32	360	0	51
Fecal strep	cts/100 ml	31	128	0	37
		TOLLGATE (116083)			
pH	units	10	8.23	7.60	7.90
Conductivity	µmhos	10	201.00	82.00	151.20
Dissolved solids	mg/l	10	134.00	72.00	105.80
Calcium	mg/l	10	21.44	9.22	15.63
Magnesium	mg/l	10	9.60	3.40	6.32
Sodium	mg/l	10	8.04	3.91	6.44
Phosphorous	mg/l	10	0.11	0.04	0.07
Nitrate	mg/l	10	0.42	0.00	0.07
SiO_2	mg/l	10	54.00	23.50	30.43
Sodium Adsorption Ratio	ratio	10	0.38	0.28	0.34
Suspended solids	mg/l	10	45.00	0.00	8.30
Total coliform	cts/100 ml	32	1240	5	194
Fecal coliform	cts/100 ml	32	700	0	87
Fecal strep	cts/100 ml	31	230	0	65

TABLE 1.--Water quality characteristics, Reynolds Creek Watershed sampling site (Continued)

Parameter	Units	No. of Samples	Maximum	Minimum	Average
		BELOW DOBSON (135008)			
Total coliform	cts/100 ml	31	756	4	177
Fecal coliform	cts/100 ml	32	524	0	74
Fecal strep	cts/100 ml	31	340	0	57
		DOBSON (135017)			
Total coliform	cts/100 ml	31	1820	16	244
Fecal coliform	cts/100 ml	31	480	4	78
Fecal strep	cts/100 ml	30	310	2	33
		ABOVE DOBSON (135018)			
Total coliform	cts/100 ml	32	400	4	100
Fecal coliform	cts/100 ml	32	160	0	31
Fecal strep	cts/100 ml	31	332	0	45
		DEMOCRAT (155019)			
Total coliform	cts/100 ml	29	680	5	136
Fecal coliform	cts/100 ml	29	162	0	25
Fecal strep	cts/100 ml	28	634	0	68
		REYNOLDS MOUNTAIN WEIR (166074)			
Total coliform	cts/100 ml	30	2240	36	462
Fecal coliform	cts/100 ml	30	1000	4	171
Fecal strep	cts/100 ml	29	184	0	50
		REYNOLDS MOUNTAIN SPRING (176512)			
Total coliform	cts/100 ml	24	52	0	5
Fecal coliform	cts/100 ml	24	10	0	<1
Fecal strep	cts/100 ml	23	2	0	<1

Chemical quality of runoff from irrigated pastureland and rangeland:

As noted in previous years, considerable change occurs in chemical concentrations of streamflow between sites on rangeland and those receiving runoff from irrigated fields. The same situation prevailed in 1976. A comparison of selected chemical parameters is given on Figure 2 for site 116083, located on rangeland, and site 036068, which receives runoff from irrigated land.

The same trends occurred in 1976, during the irrigation season as during previous years. Ionic concentrations increase to maximum toward the late summer-early fall as streamflow decreases and irrigation return flow increases. The only variation in this pattern is with the nutrients, phosphate and nitrate, which are more directly associated with streamflow. Both phosphate and nitrate, although total concentrations are low, increase with flow and with suspended concentrations.

A rapid salinity increase (EC), occurs during late summer. A sodium alkali hazard (SAR) does not appear to exist. No appreciable deterioration in chemical quality of Reynolds Creek occurred during the remainder of the year and there is no evidence that livestock operations on the Reynolds Creek Watershed are a cause of concern regarding chemical pollution.

Comparison of nonpoint sources of pollution for winter cattle feeding versus summer grazing:

The surface water of Reynolds Creek is classified as Secondary Contact Recreational Waters by the Idaho Department of Health and Welfare. To exceed bacterial quality standards in this classification, water samples must contain more than 800 counts per 100 mls for fecal coliform concentrations. Over a 4-year period, samples were collected at each of 11 sites along Reynolds Creek and analyzed for fecal coliform bacteria concentrations. The results of this analysis were put together in 1976, for comparison with Idaho's water quality standards for bacteria concentrations for secondary recreational waters. The results are given on Table 2 and show that those stream segments located on open range, where cattle graze from April through September, are far less likely to be nonpoint sources of pollution that those stream segments located adjacent to pastures where cattle are concentrated during winter feeding operations. Site 000100, located at the confluence of Reynolds Creek and the Snake River, reflects year around pasture use immediately upstream. Site 166074, located on open range, reflects the presence of cattle in above normal concentrations during grazing season, because of the small drainage area above this site and because the area is the main source of water in the entire grazing allotment.

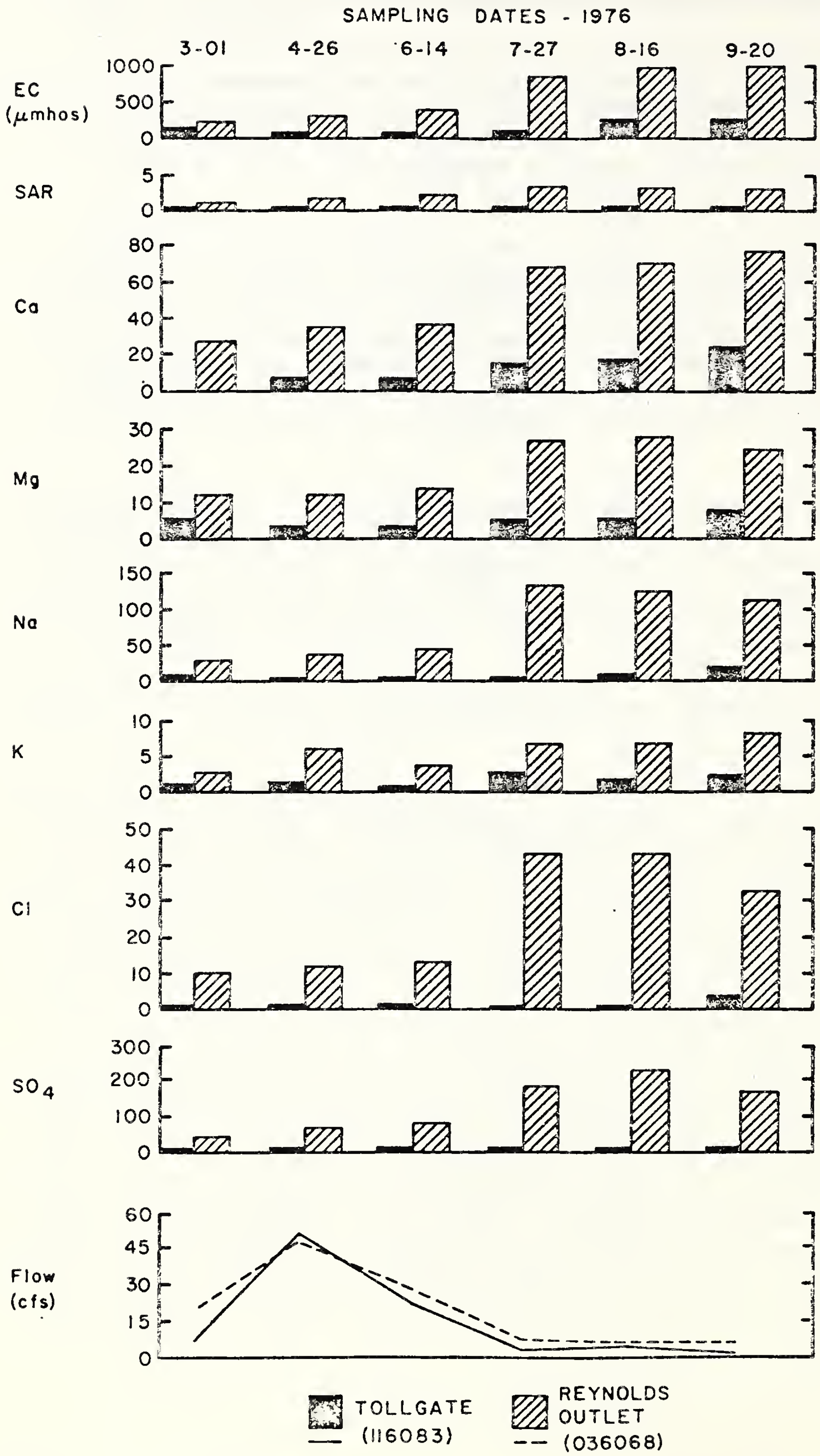

Figure 2. Variation in major chemical constituents (mgl) and streamflow between site 116083, on grazing land, and site 036008, on irrigated land.

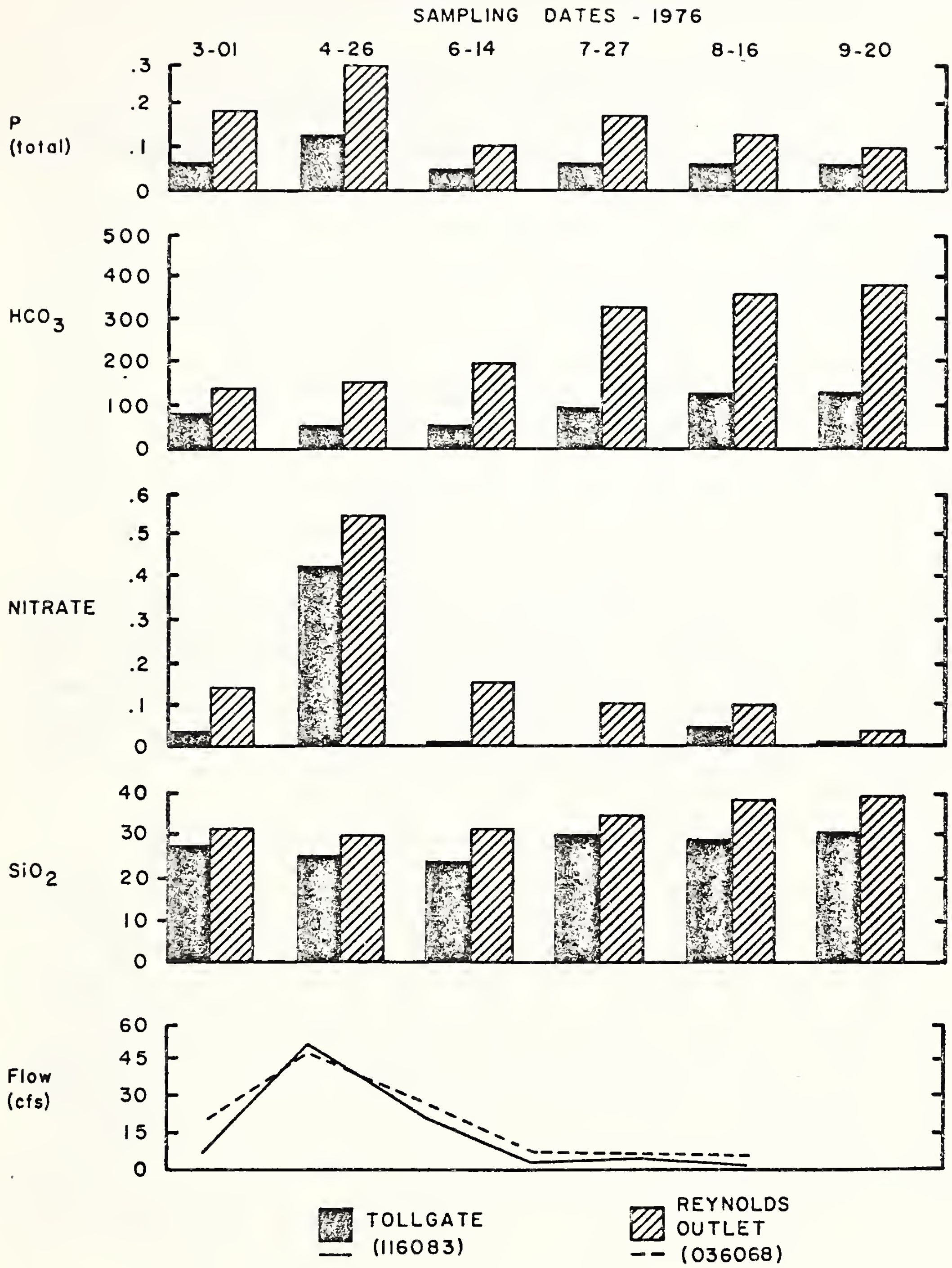

Figure 2. Continued

TABLE 2.--Comparison of % times bacterial water quality standards exceeded on rangeland sites vs pasture sites

Site No.	Number of Samples	Max. Cnts.	Min. Cnts.	No.Times Standard Exceeded	% Times Standard Exceeded	Range (+) Pasture(-)
000100	61	4550	0	12	19.7	(-)
000200	49	750	0	0	0	(+)
036068	107	864	0	2	1.9	(+)
056047	107	400	0	7	6.5	(-)
077071	80	1220	0	6	7.5	(-)
087072	101	1680	0	8	7.9	(-)
106018	86	560	0	0	0	(+)
116083	98	700	0	0	0	(+)
135008	90	524	0	0	0	(+)
155019	95	1160	0	1	1.1	(+)
166074	80	3000	0	4	5.0	(+)

These data reflect the difference in nonpoint sources of pollution between summer and winter feeding operations on typical rangeland cattle operations. There appears to be no significant problem on open range, as 5 percent or less of the samples exceeded the standards; whereas, for locations adjacent or below pastures where cattle are concentrated for winter feeding, nearly 20 percent of the stream samples exceeded the standards for secondary recreational waters.

Changes in bacterial concentrations during major runoff events:

Detailed sampling was done for bacterial analyses through several runoff events from snowmelt. Analyses of these samples show that considerable variations in coliform concentrations occur during changes in streamflow. Figure 3 gives the results of data collected during two peak flow events at site 087072. Both total and fecal coliform counts increase rapidly as the water level rises in the stream channel. On May 1, peak concentrations for fecal coliform occurred about one hour before peak concentration for total coliforms, and about two hours before the hydrograph peak. The relative situation was identical on May 3, except that the hydrograph peak occurred about four hours later. These same relationships have been found to occur at other sites during similar runoff events on the watershed, and show a close similarity to suspended sediment concentrations in streamflow during snowmelt runoff.

The bacteria are concentrated by the increase in flow up to a critical limit where the concentrations are then decreased by dilution as streamflow continues to rise. This variability in bacteria concentration, resulting from streamflow, is an important factor to consider when samples are taken, particularly if the results are used for checks with water quality standards.

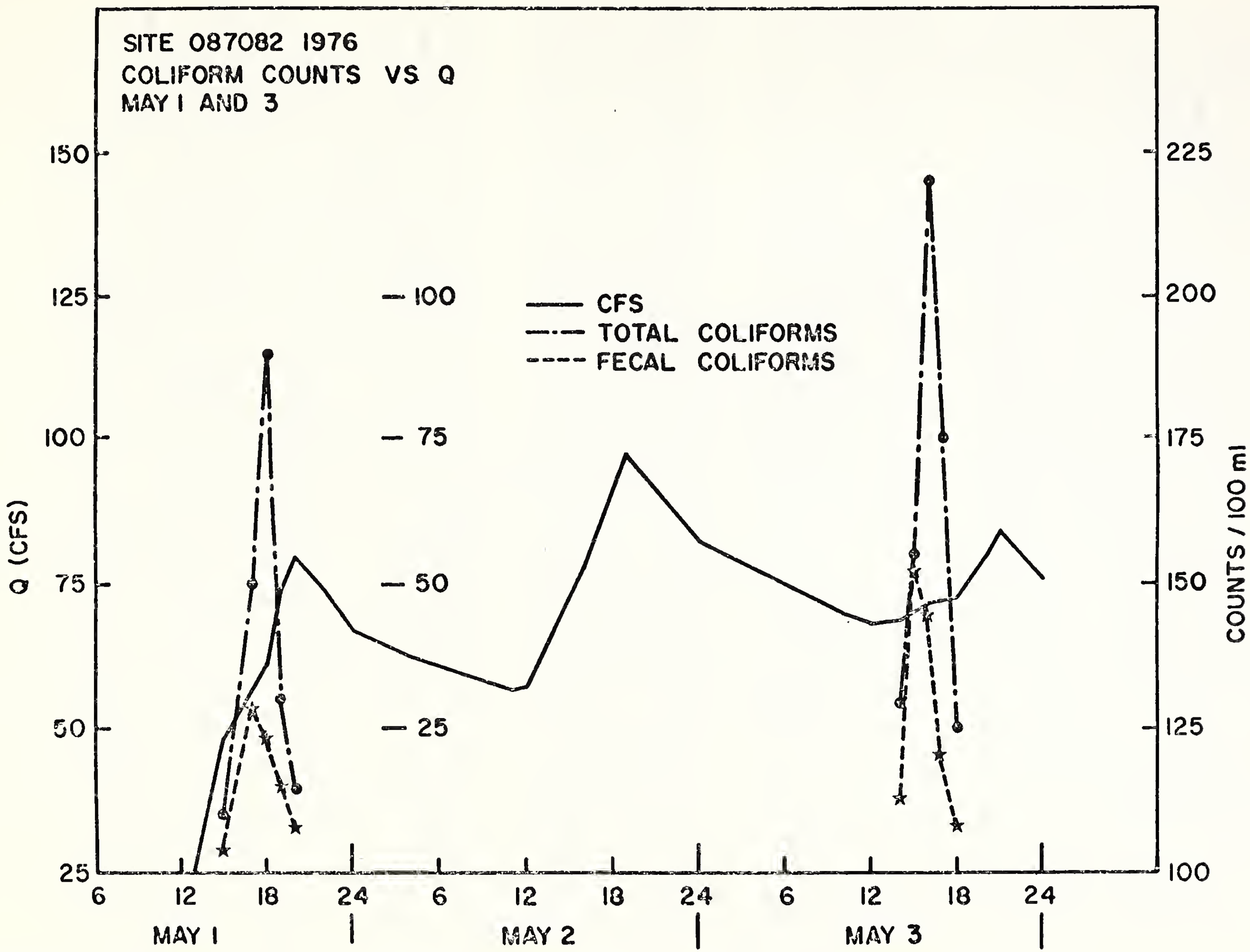

Figure 3. Variation in bacterial concentration with runoff during snowmelt runoff.

Aquatic Insect Investigations:

A grasshopper invasion in 1975 resulted in the application of malathion (95 percent technical grade, at the rate of 8 fluid ounces per acre) over 22,500 acres of rangeland on the Reynolds Creek Watershed. Samples of immature aquatic insects were collected before, during, and after spraying, to determine the effect of the pesticide on these non-target organisms. The Surber square-foot sampler was used for sampling the insect populations. Five samples were taken for each sample date. After each sample was taken, the contents of the net were immediately placed in a porcelain pan, and the macroscopic life forms were removed, classified as live or dead, and preserved in ethyl alcohol. This enabled examination and counting of all specimens in the laboratory.

Due to time and personnel limitations, it was not possible to perform the same kind of sampling in an untreated control area at this time. However, since no pesticide application was anticipated in 1976, the sampling was accomplished once again. This was done in order to provide data for the untreated case, which would, in effect, act as control data. It would also give indication of the expected numbers of dead organisms under natural condition.

Figure 4 is a streamflow graph showing both the 1975 and 1976 sampling times. Since the area was sprayed on July 19-21, 1975, Figure 5 illustrates the mortality within the aquatic ecosystem due to the application of malathion. The ratio of dead to live organisms shows a dramatic increase on July 21, 1975, and, further, that abnormal mortality rates continued until July 30, 1975. This conclusion is very much strengthened by the 1976 data, also plotted as a function of time in Figure 5.

The largest dead/live ratio found in the 1976 samples is 0.41, while the largest ratio in 1975 was 1.30. The mean of the 1976 sample set ratios is 0.24, with a standard deviation of 0.08, while the mean of the 1975 sample set ratios is 0.42, with a standard deviation of 0.36.

The 1975 and 1976 samples are comparable in that the same reach of stream was sampled both years over approximately the same time period. However, the flows in 1975 were much higher. Figure 4 is a time plot of the 1975 and 1976 flows. While it does not seem likely that higher flows would be responsible for larger dead/live ratios, the possibility cannot be entirely discounted. On the other hand, one can speculate that if the spray had been applied in 1976, mortality rates could have been even greater, due to the low volumes of water and the resulting decrease in dilution and dispersion of the pesticide.

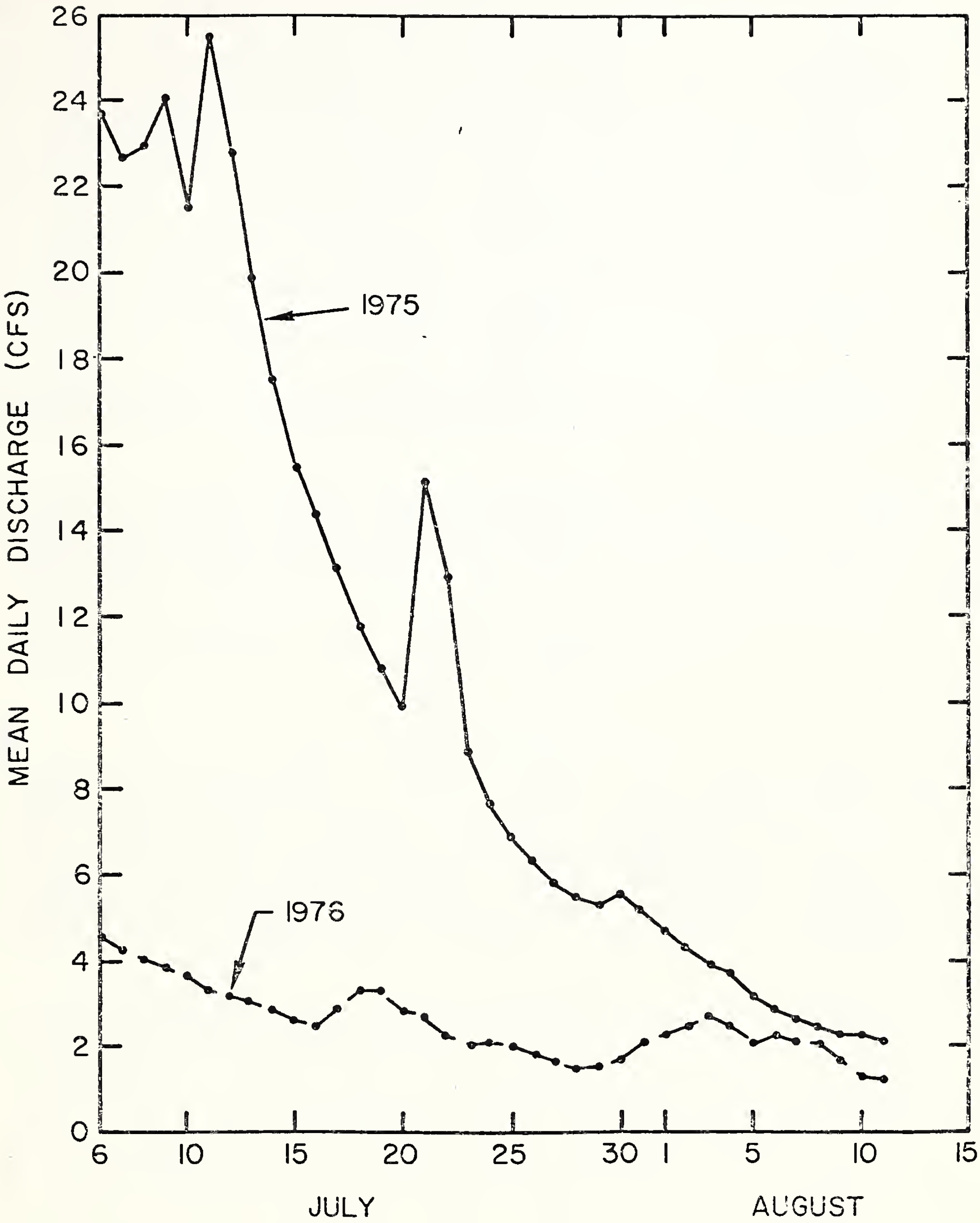

Figure 4. Mean daily discharge for channel segment sampled for aquatic insects in 1975 and 1976.

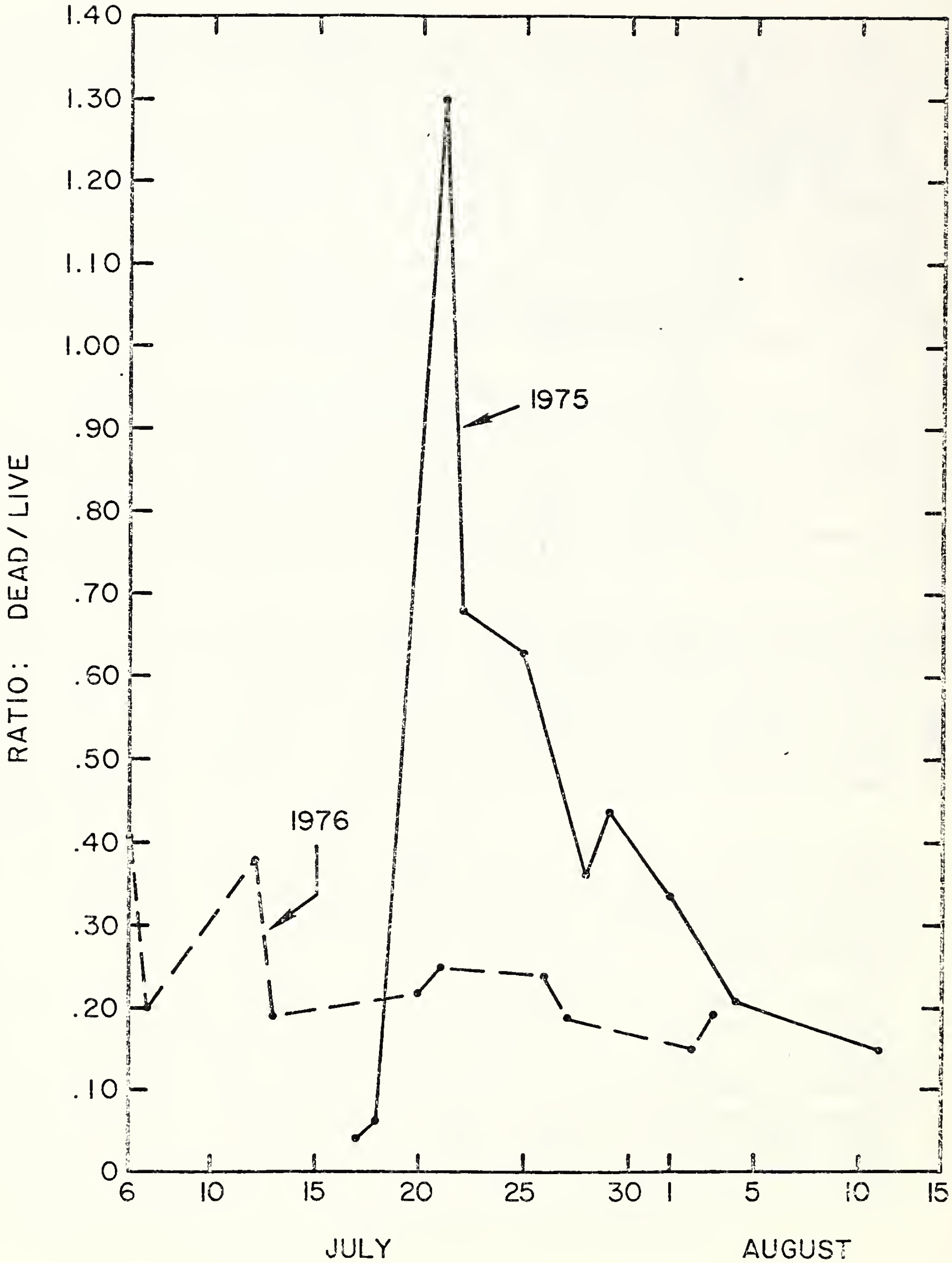

Figure 5. Ratio of dead to live aquatic insects, 1975, 1976.

Boise Front

Water quality of rest-rotation grazing allotments:

Sampling sites have been established on the Boise Front in the Lucky Peak Resource Management Unit to determine the effects a rest-rotation grazing management practice might have on the quality of runoff waters. Samples are collected semi-monthly from streamflow at two gaged sites, one ungaged site, and at two springs. Additional sites, and more frequent sampling, may be added at the beginning of the grazing season. Samples are analyzed to determine concentrations of the major chemical constituents, and for concentrations of coliform bacteria, and suspended sediment. These are the same parameters for which analyses are made for the Reynolds Creek water quality program.

Baseline data has been obtained since November 1976, to give a sufficient background of information prior to the start of the grazing season.

Comparisons of results between grazed and rested fields will be made, where possible. Data from the rest-rotation management practice will be compared with data available from different levels of management in other resource units.

No results are available from this study for 1976.

SIGNIFICANT FINDINGS

1. Analyses of bacteria data collected over a 4-year period show that water quality standards for Reynolds Creek (secondary recreational) were exceeded in only 0 to 5 percent of the samples collected on rangeland, but from 5 to 19 percent of the samples from sites along irrigated pastures where cattle are fed during the winter. This further indicates that nonpoint sources of pollution are not significant on rangeland.

2. Investigations of variations in bacterial concentrations with streamflow indicate that, during a runoff event, concentrations of bacteria increase in much the same pattern as suspended sediment. Peak concentrations of both total and fecal coliform bacteria, peak earlier than the peak of streamflow. This is an important factor if sampling for bacteria concentration during changes in streamflow.

3. No significant changes occur in the chemical quality of streams on rangeland, resulting from cattle grazing operations. Changes in nutrient levels were unchanged during the summer grazing period.

4. Samplings of immature aquatic insects during 1975, when the rangeland was treated with malathion, and 1976, when no treatment was applied, indicate that the application of this particular pesticide results in a large mortality among nontarget aquatic organisms. The effects of the pesticide appears to be short-lived, since aquatic populations recovered to pretreatment levels within a few weeks.

WORK PLAN FOR FY 78

Reynolds Creek

1. Both the tube and membrane filter methods will be used to determine bacterial concentrations associated with suspended sediment during major runoff events. Results will permit the separation of free coliform bacteria from those adsorbed on suspended sediment during runoff.

2. Soil biological activity will be investigated to determine background coliform counts and survival of fecal coliforms on rangeland, following removal of cattle at the end of the grazing season. Results will provide information on sources of bacteria in streamflow under different soil, vegetative, climatic, and management conditions.

3. A study has just been started to determine best management practices for use on irrigated pastures used for winter cattle feeding operations to reduce nonpoint sources of pollution in runoff from these fields.

4. Aquatic insect investigations will be conducted if the area is again treated. Pesticide concentrations in the water will also be determined.

Boise Front

1. Water quality characteristics of a rest-rotation grazing management practice will be determined and compared to date previously collected on a deferred rotation management practice and an unmanaged grazing practice.

REPORTS AND PUBLICATIONS

Stephenson, G. R. and L. V. Street 1976
Quality of runoff from nonpoint sources on a southwest Idaho rangeland watershed. Presented at the 43rd Annual Meeting of the Northwest Pollution Control Administration, Seattle, Washington. October.

Stephenson, G. R. and L. V. Street 1976
Water quality investigations on the Reynolds Creek Experimental Watershed, Southwest Idaho -- a 3-year summary. Report on Water Quality, Cooperative Agreement No. 14-11-0001-4162(N).

Stephenson, G. R. and L. V. Street 1976
Bacterial variations in streams from a southwest Idaho rangeland watershed. Submitted to Journal of Environmental Quality.

RUNOFF AND SEDIMENT

Title: Sediment yield and runoff from rangeland watersheds

Personnel Involved:

C. W. Johnson, Research Hydraulic Engineer	Plan programs and procedures; design and construct facilities for sediment studies; perform analyses and summarize results.
G. R. Stephenson, Geologist	Determine geologic and geomorphic parameters related to sediment yield.
C. L. Hanson, Agricultural Engineer	Test various components in sediment models most applicable to rangelands
R. L. Engleman, Mathematician	Perform data compilation and assist in analyses.
J. P. Smith, Hydrologic Technician	Data collection, compilation, and analyses.
M. D. Burgess, Electronic Technician	Designs, constructs, and services electronic sensors and radio telemetry systems.

Date of Initiation: September 1, 1969

Expected Termination Date: Continuing

INTRODUCTION

Reynolds Creek

Information on sediment transport and yield is needed for millions of acres of predominantly sagebrush rangeland under government land management and private ownership in the Northwestern United States. There is a growing concern for soil losses from intensively grazed rangelands, sediment damage to reservoirs, and erosion of stream channels.

Most rangeland watersheds in the Intermountain Northwest have large areas of relatively steep hillslope topography, and these areas need to be delineated for treatment to reduce erosion. Also, sediment yield information is needed for evaluating the benefits of watershed management and land treatment programs of the Bureau of Land Management and Soil Conservation Service.

Range sites found in the Reynolds Creek Experimental Watershed represent a large percentage of the rangeland in the Northwest, and studies of sediment yield are essential for developing sound management practices and planning appropriate multiple use of these lands. Good land management decisions require information on how vegetative changes, fencing, and land use alter the sediment yield of rangeland watersheds.

The sources of these sediments need to be determined so that research data can be used to predict sediment yield for ungaged areas in terms of available information on soils, climate, physiography, and use.

Boise Front

Runoff, erosion, and sediment yield from rangelands on the Boise Front have been of great concern for many years, because of range fires, severe storms, and intensive recreational use and grazing on the area. Actively eroding gullies and steep, poorly-vegetated slopes contribute a major portion of the sediment yield from these lands. Therefore, sediment sources and amounts need to be determined for thunderstorms, snowmelt, and frozen-soil runoff events. Also, the effectiveness of the rest-rotation and deer management programs in reducing sediment production needs to be evaluated.

Objectives:

Reynolds Creek

1. To determine precipitation-snowmelt-runoff relationships and to test watershed runoff models on rangeland watersheds.

2. To determine the relationships between sediment yield and variables describing hydraulic and hydrologic factors and site and watershed characteristics that influence sediment yield.

3. To test presently used erosion and sediment yield procedures, utilizing Reynolds Creek Watershed data.

4. To develop and test improved erosion and sediment yield prediction procedures for rangeland watersheds in the northwest.

Suspended and bedload sediment yields from watersheds are measured by pumping sediment samplers, catchments, and hand sampling. A wide range of slope length, slope gradient, aspect, and relief ratio are represented. Rainfall intensity and duration data are available from a network of precipitation gages, and snow data are available from snow courses, snow pillows, and other snow-measuring sites. Also, data on cover, topography, and soil factors (including frost depths) which influence erosion and sedimentation, are available through other investigations at the Northwest Watershed Research Center.

Boise Front

1. To determine the effects of the rest-rotation grazing and deer-management systems on water and sediment yields.

2. To establish a data base for evaluating runoff, erosion, and sediment yield models.

3. To compare Boise Front runoff and sediment yield with other rangeland areas.

Runoff and sediment yield from grazed and ungrazed watersheds during major storm events will be analyzed to determine the influence of the grazing management system. Gullies and steep, poorly vegetated hill-slopes will be delineated and periodically surveyed to determine amounts and sources of sediment measured in streams. Data will also be used to compare runoff and sediment yield model results on the Boise Front with rangeland watersheds in Reynolds Creek.

PROGRESS

Reynolds Creek

Runoff and sediment measurement:

Watersheds active through 1976 are listed in Table 1. Locations of measurement sites are shown in Figure 1. The two remaining runoff-sediment plots at Nancy Gulch and Nettleton pasture were discontinued in June 1976.

Runoff in the 1976 water year:

Monthly and yearly runoff for the 1976 water year at three selected streamflow measuring stations are summarized in Table 2 and compared with the average of record. The data shows that 1976 water yields were about 88, 98, and 104 percent of average at the Reynolds Outlet, Reynolds Tollgate, and Reynolds Mountain stations, respectively. Water yields in 1976 were about 40, 61, and 64 percent of recorded maximums at these stations.

Peak streamflow rates at the three selected stations in 1976, compared with previous years, are listed in Table 3, and show that peak streamflow rates were generally much below average and the second lowest of record. Intense rainfall in June, July, and August did not produce significant increases in streamflow in 1976.

Snowmelt, rain, and frozen soil combinations produced 0.05-inch of runoff at the Nancy Gulch watershed and 0.01-inch runoff at the Flats watershed in January 1976. However, peak streamflow at the Reynolds Outlet stations was only 99 ft^3/sec from this event and contributions from watersheds at elevations above 5000 feet were minimal.

TABLE 1.--Watersheds instrumented for runoff and sediment measurement, Reynolds Creek Watershed, 1976.

Watershed NAME	No.1/	Drainage Area (Acres)	Runoff Measuring Device	Suspended Sediment Sampler	Bedload Sediment Sampler
Reynolds Creek Outlet	1	57700	SCOV Weir	P.S. 67 Pump	Helley-Smith
Salmon Creek	2	8990	Drop-Box Weir	Hand Held	Helley-Smith
Murphy Creek	3	306	Drop-Box Weir	Hand Held	Helley-Smith
Macks Creek	4	7846	Drop-Box Weir	P.S. 67 Pump	Helley-Smith
Flats	5	2.24	V-Notch Weir	Single Stage	Detention Tank
Nancy Gulch	6	3.1	V-Notch Weir	Single State	Detention Tank
Lower Sheep	7	33	Drop-Box Weir	Hand Held	Detention Box
Reynolds Tollgage	8	13453	Drop-Box Weir	P.S. 67 Pump	Helley-Smith
Dobson Creek	9	3482	Parshall Flume	Hand Held	Helley-Smith
Reynolds Mountain	10	100	V-Notch Weir	Chickasha Pump	Detention Box

1/ Numbers designate locations of weirs and plots in Figure 1.

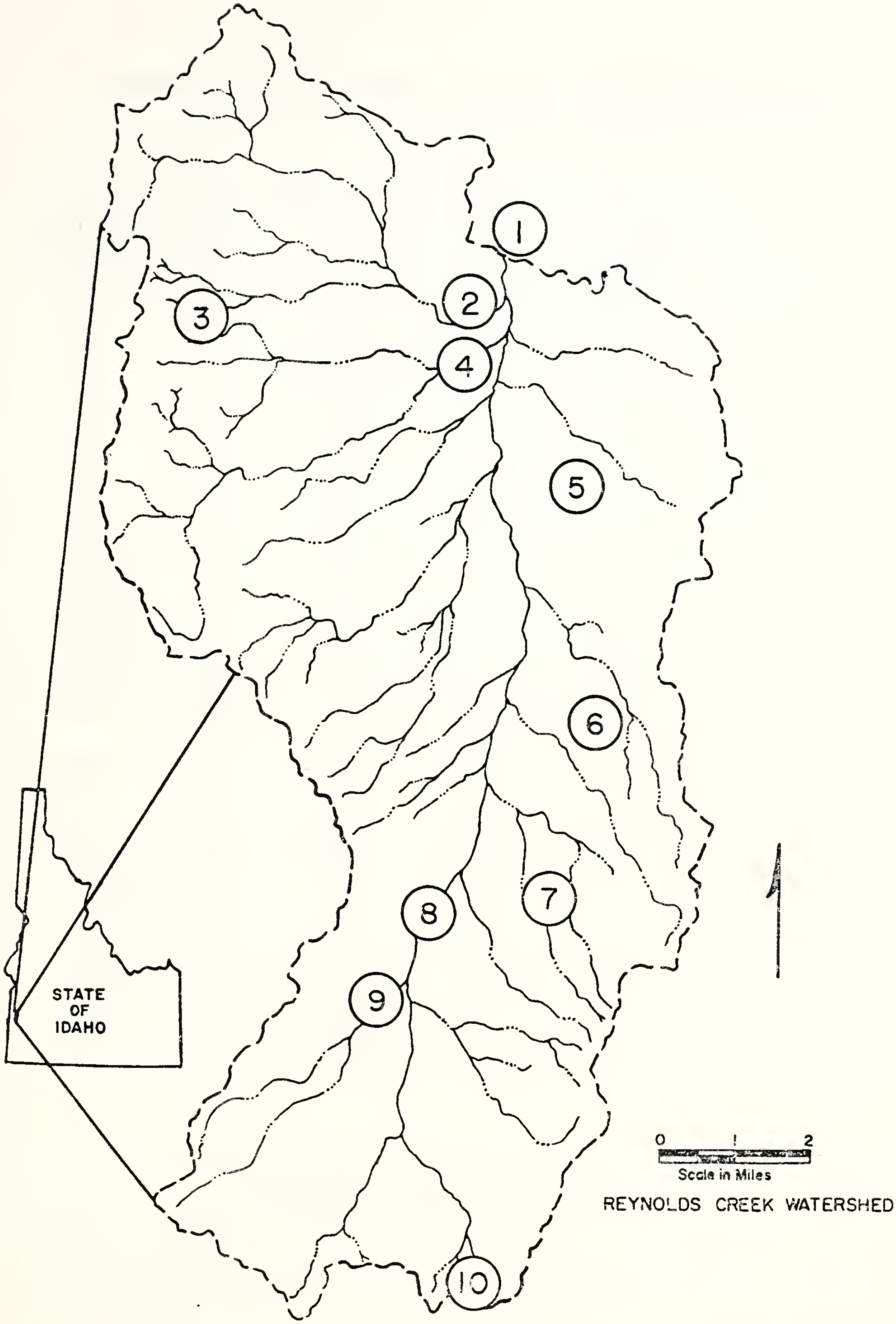

Figure 1. Locations of runoff and sediment stations, Reynolds Creek Experimental Watershed, 1976. See Table 1.

Table 2.--Runoff at selected stations on Reynolds Creek Watershed, 1976 water year compared with average of record.

Month	Runoff in Inches					
	Reynolds Creek at Outlet 1/		Reynolds Creek at Tollgate 2/		Reynolds Mountain East Watershed 3/	
	14-Year Average	1976 Water Year	11-Year Average	1976 Water Year	14-Year Average	1976 Water Year
October	.027	.089	.096	.184	.145	.288
November	.052	.092	.163	.173	.255	.361
December	.193	.227	.256	.513	.432	.665
January	.459	.230	.713	.287	.457	.342
February	.289	.162	.488	.274	.463	.246
March	.506	.280	1.163	.552	.633	.252
April	.614	.634	1.876	2.687	2.786	3.035
May	.663	.820	3.491	4.083	10.406	13.604
June	.338	.214	1.650	.970	5.172	2.907
July	.052	.041	.302	.177	.610	.344
August	.023	.030	.058	.083	.116	.175
September	.015	.024	.041	.064	.087	.136
Total	3.231	2.843	10.297	10.047	21.562	22.355
Percent of Average		88		98		104

1/ Drainage area: 90 mi^2, Station 036068, Outlet Weir.

2/ Drainage area: 21 mi^2, Station 116083, Tollgate Weir.

3/ Drainage area: 100 acres, Station 166076, Reynolds Mtn. East Weir.

TABLE 3.--Yearly peak streamflow rates and dates of occurrence, selected Reynolds Creek Watershed Stations, 1963-1976.

	Reynolds Creek Outlet Weir		Reynolds Creek Tollgate Weir		Reynolds Mountain East Weir	
Water Year	Date	Peak Flow (cfs)	Date	Peak Flow (cfs)	Date	Peak Flow (cfs)
1963	Jan. 31	2331	--	--	Apr. 29	4.16
1964	Jan. 25	188	--	--	May 16	3.60
1965	Dec. 23	3850	--	--	Dec. 23	10.70
1966	Apr. 1	59	Apr. 1	59	May 5	1.43
1967	June 7	265	June 7	288	May 22	5.44
1968	Feb. 21	327	Feb. 21	186	Aug. 10	1.48
1969	Jan. 21	900	Jan. 21	405	May 12	3.88
1970	Jan. 27	729	Jan. 27	240	May 17	5.89
1971	Jan. 18	540	May 6	193	May 4	5.77
1972	Mar. 2	678	Mar. 2	271	June 6	6.26
1973	Apr. 17	166	Apr. 17	147	May 8	3.31
1974	Mar. 29	291	Mar. 29	195	May 7	4.33
1975	Mar. 25	281	June 2	231	June 2	9.27
1976	Apr. 5	140	May 10	130	May 13	4.59
Average		768		213		5.01

Sediment yields in 1976:

Sediment yields in the 1976 water year were only about 10 and 20 percent of the 1967-76 average at the Reynolds Outlet and Reynolds Tollgate stations, respectively. Yields were lower than normal because of snowmelt conditions and consequent low peak streamflow. Streamflow diversion for irrigation between the Reynolds Outlet and Reynolds Tollgate stations caused the reduced yield at Reynolds Outlet.

Maximum suspended sediment concentrations were 3150 and 1060 mg/l at Reynolds Outlet and Reynolds Tollgate stations, much below that of most years.

Study of Flaxman sediment yield equations:

Through cooperation with the Soil Conservation Service, ARS scientists located at Morris Minnesota and Oxford, Mississippi, obtained and analyzed soil samples and collected hydrologic data to test the Flaxman[1/] multiple regression equations on 71 watersheds. Comparisons of measured with predicted yields, having less than 100 percent error, showed that a log transformation of regression variables was preferable to linear factors in 110 of 213 cases. Also, equations with 5 rather than 4 independent variables were preferable in 50 of 71 cases. The equations performed best in predicting sediment yields from western rangelands, and performed very poorly in predicted yields from forested and cultivated watersheds; probably because the equations were originally derived from western rangeland watershed data. The Flaxman, 1972, equations should be applied with extreme caution on individual watersheds.

Bedload sediment sampling:

Helley-Smith, 1971[2/] bedload sampler bag size was increased from 340 in^2 to 930 in^2 to determine the errors caused by organic debris and sediment clogging the bag mesh. The successful tests showed that small sampler bags caught 27 percent as much sediment as the large bags during several spring runoff events. The large sampler bags provide accurate data to determine bedload transport rates during storm runoff events. Computer programs, to determine accurate sediment transport rates for all major recorded events, are now being written.

1/ Flaxman, E. M. 1972
Predicting sediment yield in western United States. Amer. Soc. Civil Engin., J. Hydraulics Div., 98(HY2): 2073-2085, December.

2/ Helley, E. J. and W. Smith. 1971
Development and calibration of a pressure difference bedload sampler. U.S. Dept. of Interior, Geological Survey, Water Resources Div., Open File Report, Menlo Park, California, 18 pp.

Soil Frost Study:

Severe winter floods in Idaho and surrounding areas are often caused by rain and/or snowmelt on frozen soil. Measurements of frost penetration and thawing are critical in flood analysis and watershed modeling for such events.

Frost measurements were made from January through spring 1976, at 11 measuring sites. These were read weekly except the sites at Reynolds Quonset weather station and Lower Sheep Creek weather station, which were recorded every four hours. Gypsum soil water blocks at depths of 5, 10, 15, 20, and 30 cm (2, 4, 6, 8, and 12 in) were used to measure the frost depth at each site. Soil temperature was measured to 100 cm (39.4 in) at the Quonset and two depths, 10 cm (4 in) and 20 cm (8 in) at Lower Sheep. Also, frost penetrometers of the type described by Harris, 1970[3/], were installed at six locations.

Boise Front

Instrumentation for runoff, sediment, and frost measurement:

Runoff and sediment stations were completed on Upper Maynard Gulch and Highland Creek in October 1976. Also, stations on Lower Maynard Gulch and Cottonwood Creek near Boise were chosen and scheduled for construction when landowner approval is received. See Introduction Figure 1 for station locations. Streamflow stations are instrumented for continuous runoff measurement and for intermittent suspended sediment sampling by automatic pump samplers and bedload sampling by Helley-Smith samplers. Hydrologic data analysis and frequent sediment sampling are planned during major storm events to compare sediment contributions from grazed and ungrazed areas.

Gypsum soil water blocks for soil frost determinations, were installed at each of the rain gage sites on the Boise Front project and penetrometers were installed at weather station.

SIGNIFICANT FINDINGS

Runoff at Reynolds Creek stations in the 1976 water year varied from 88-104 percent of the 14-year average; however, sediment yields were only 10-20 percent of the 1967-76 averages, because of low peak streamflows.

Sediment yield predictions, using Flaxman sediment yield equations, compared favorably with averages of measured values from western rangeland

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3/ Harris, Alfred Ray. 1970
Direct reading frost gage is reliable, inexpensive. Research Note NC-89, North Central Forest Experiment Station, Forest Service, USDA. 2 p.

watersheds. However, predicted yields from individual watersheds were highly variable and the equations should be cautiously applied. The equations performed poorly on forested and cultivated watersheds.

The development of larger bags for Helley-Smith bedload samplers showed that small standard bags were easily clogged with organic debris and sediment during peak runoff events. The improved sampler bags provide accurate data for computation of bedload transport rates under a wide range of streamflow conditions.

WORK PLAN FOR FY 78

Reynolds Creek

1. Collect runoff and sediment data at active watershed stations.

2. Develop relationships of measured sediment transport to storm and channel factors for rainfall and snowmelt events. Sediment grain-size characteristics will be determined for various streamflow rates.

3. The influence of frozen soil on runoff and sediment production during typical rain and snowmelt events will be studied.

Boise Front

1. Delineate and survey actively eroding gullies and steep hillslopes on watersheds instrumented for runoff and sediment measurement.

2. Complete instrumentation and collect and analyze watershed runoff and sediment data to compare grazed and ungrazed areas.

3. Determine factors in the Universal Soil Loss Equation to represent rangeland conditions and characterize and use the equation to predict soil losses.

REPORTS AND PUBLICATIONS

Johnson, C. W. and C. L. Hanson 1976
Sediment sources and yields from sagebrush rangeland watersheds. Interagency Sedimentation Conference, Denver, Colo. pp 1-71 to 1-80. March.

Johnson, C. W., C. A. Onstad, and C. K. Mutchler 1976
Evaluation and prediction of sediment yield by Flaxman methods. Report of cooperative ARS-SCS study - 26 pp. January 1977. Presented at the Annual Meeting of the American Society of Agricultural Engineers, Chicago, Ill. December 14-17.

Johnson, C. W., R. L. Engleman, J. P. Smith, and C. L. Hanson 1977
Using Helley-Smith bedload samplers. (Submitted for publication in American Society of Civil Engineers, Jour. of the Hydraulics Division. January.

WATERSHED MODELING

Title: Developing, testing, and evaluating watershed models

Personnel Involved:

C. L. Hanson, Agricultural Engineer	Coordinator of watershed modeling, ET, and precipitation modeling
D. L. Brakensiek, Research Hydraulic Engineer	Streamflow and infiltration modeling
G. R. Stephenson, Geologist	Subsurface flow and water quality modeling
C. W. Johnson, Research Hydraulic Engineer	Runoff, erosion, and sediment yield modeling
J. F. Zuzel, Hydrologist	Snowmelt modeling
R. L. Engleman, Mathematician	Computer application and program analysis

Date of Initiation: June 1974

Expected Termination Date: Continuing

INTRODUCTION

The development of computer hardware and software over the past decade has provided the impetus for many significant advances in the development of watershed models. At the Northwest Watershed Research Center, modeling activity focuses on combining and interrelating component models, such as snowmelt, infiltration, runoff, evapotranspiration, streamflow and erosion, and sediment yield into watershed models.

The watershed models provide output data for such needs as evaluation of watershed management practices by predictions of water quality, sediment yield, storm runoff, and rangeland forage productivity.

Objectives:

1. Test existing watershed models with Reynolds Creek Watershed data.

2. Improve watershed model components for a sagebrush rangeland watershed, which present models do not satisfactorily represent.

3. Forecast with models, the influence of land use and treatment and/or management, such as grazing systems, on watershed runoff quality and quantity.

4. Test the application of watershed models to other sagebrush rangeland watersheds in the Northwest.

PROGRESS

Watershed Model:

The USDAHL-74 revised model of watershed hydrology (Holtan, Stiltner, Henson, and Lopez, 1975)[1/] was tested on the 205-acre Summit Basin, a subwatershed of the Reynolds Creek Watershed, using hydrologic data for 1967, 1968, and 1969. This watershed was selected as the first test of the model, because the precipitation input was not affected by a snowpack.

The model simulated soil water adequately with the exception of periods during late summer and fall, when the model overestimated soil water. The reason for this overestimation is not known for certain, but it may be because sagebrush and the annual grasses grew during the fall when water was available. The model, during this period, did not account for water use by plants, as the temperatures are below freezing for short periods of time.

The model did not simulate runoff adequately. Analysis of the limited runoff information indicated that actual watershed runoff is more sensitive to precipitation amount, whereas the model runoff routine is more sensitive to precipitation intensities. The 11-year (1965-1975) mean annual runoff from the Summit Basin is only 0.036 inch, which would be very difficult to simulate. The model does not account for frozen soil conditions and the model's snowmelt capability routine is very limited.

Infiltration Process Modeling:

Infiltration data for soil types ranging from sand to clay were utilized to evaluate procedures to estimate the effective capillary pressure parameter in the Green and Ampt infiltration equation, shown as Equation (1).

$$\frac{Kt}{f} = L - S \ln \frac{S+L}{S}$$

1/ Holtan, H. N., G. J. Stiltner, W. H. Henson, and N. C. Lopez 1975 USDAHL-74 Revised Model of Watershed Hydrology, USDA, Technical Bulletin No. 1518.

where: K - effective hydraulic conductivity, cm/min

S - effective capillary pressure, cm

f - fillable porosity

A simple regression estimator, 0.76 P_b, where P_b is the desorption bubbling pressure, was found to be quite accurate. The air-entry value could be used in lieu of the bubbling pressure.

Infiltrometer data from a soil type in South Dakota, was utilized in another study for estimating all three parameters of the Green and Ampt equations, i.e., f, K, and S. Since this data sampled several sites on the same soil type, spatial variation of the parameters was also studied. A statistical procedure was developed and successfully applied to individual test sites for estimating the three parameters. Spatially lumped parameter values were estimated for the particular soil type. Sensitivity analysis of the three parameters indicated that for infiltration amounts, runoff volumes, and runoff peak estimates, the K-parameter is two to three times more critical than the S-parameter and the fillable porosity parameter, C, is about 1.5 times more critical than the K-parameter. Thus, in estimating the parameters for field application, the fillable porosity must be determined most accurately. Fortunately, field measurements can readily be made for determining fillable porosity. Unfortunately, the conductivity parameter is not easily determined in the field or laboratory. However, calculated values may be reasonably made from moisture characteristics. The capillary pressure parameter can be satisfactorily estimated from moisture characteristics.

Field infiltrometer tests should be considered for field evaluation of watershed soil infiltration characteristics. This approach can estimate all three parameters and, at the same time, give a measure of parameter spatial variation.

Snowmelt modeling:

Progress is reported under snow section.

SIGNIFICANT FINDINGS

The USDAHL-74 watershed model estimated soil water adequately except for periods in late summer and fall on the Summit Basin, a subwatershed of the Reynolds Creek Watershed. The model did not simulate the small amounts of observed runoff adequately. The very small amounts of runoff that may be caused by snowmelt and/or rain, make the runoff regime of this semiarid watershed very difficult to model. The model does not account for frozen soil conditions and the model's snowmelt routine is of limited use, which probably makes the model's usefulness in the Pacific Northwest somewhat limited.

The Green and Ampt infiltration equation parameters can be estimated from infiltrometer data. It was established that fillable porosity is the most important equation parameter, followed by the conductivity parameter. The capillary pressure parameter is the least important, and can be estimated as 0.76 of the desorption bubbling pressure.

WORK PLAN FOR FY 78

1. Green and Ampt parameters will be estimated for Reynolds Creek Watershed soils.

2. Development of a watershed model will be initiated with the Green and Ampt equation being programmed for variable input (rainfall and/or snowmelt).

REPORTS AND PUBLICATIONS

Brakensiek, D. L. 1976
Estimating the effective capillary pressure in the Green and Ampt infiltration equation. Accepted for publication in Water Resources Research, 1977.

Brakensiek, D. L. and C. A. Onstad 1976
Applying Green and Ampt theory to infiltration modeling. Presented at the Fall Meeting, American Geophysical Union, San Francisco, December.

Brakensiek, D. L. and W. J. Rawls 1976
Utilizing an infiltrometer for making infiltration estimates. In process.

Hanson, Clayton L. 1976
Evaluation of USDAHL-74 revised model of watershed hydrology under arid rangeland conditions. Report to the USDA-SCS, June.